DUKE ENERGY®

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October 10, 2019

**VIA ELECTRONIC FILING**

The Honorable Jocelyn G. Boyd Chief
Clerk / Administrator
Public Service Commission of South Carolina
101 Executive Center Drive, Suite 100
Columbia, SC 29211

**Re:** Petition of Duke Energy Carolinas, LLC and Duke Energy Progress, LLC for Approval of CPRE Queue Number Proposal, Limited Waiver of Generator Interconnection Procedures, and Request for Expedited Review
**Docket No. 2018-202-E**

Dear Ms. Boyd:

Pursuant to the Public Service Commission of South Carolina's ("Commission") Order No. 2019-247 issued on April 9, 2019, in the above-captioned docket, Duke Energy Carolinas, LLC ("DEC") and Duke Energy Progress, LLC ("DEP") (collectively, the "Companies" or "Duke") hereby respectfully provide the Commission an update on the Companies' most recent Distributed Energy Resources ("DER") Technical Standards Review Group ("TSRG") meeting held on September 17, 2019.

The following attachments enclosed with this update provide a more detailed account of the previous TSRG meeting and issues discussed:

- **Attachment A:** September 17, 2019 Meeting Agenda
- **Attachment B:** September 17, 2019 Draft Meeting Minutes
- **Attachment C:** Proposed Sequential Switching Requirements Presentation
- **Attachment D:** Fast Track and Supplemental Review Process Presentation (EPRI)
- **Attachment E:** 2019 Interconnection Commissioning Update Presentation (AE)

As described in the Companies' June 6, 2019 Report in this docket, the TSRG webpage, https://www.duke-energy.com/business/products/renewables/generate-your-own/tsrg, provides meeting materials from each prior TSRG meeting, as well as other technical standards documents.

The next TSRG meeting is tentatively scheduled for January 2020.

Sincerely,

Rebecca J. Dulin

Enclosures

cc: Parties of Record

**Interconnection Technical Standards Review Group (TSRG)**
**Duke Energy Carolinas/Progress**
**Meeting Agenda**
**September 17, 2019**

| | |
|---|---|
| 9:00 | Safety & housekeeping – Kevin Chen, Duke |
| 9:10 | Introductions & roster – Anthony Williams, Duke |
| 9:15 | May action items report – Anthony Williams, Duke |
| 9:30 | Sequential Switching Requirements – Anthony Williams, Duke |
| 10:00 | Report on FT and SR process – Tom Key, EPRI |
| 12:00 | LUNCH (provided by Duke) |
| 1:00 | Pilot Inspection Results for DER sites operating prior to commissioning tests – Kevin Chen, Duke |
| 2:15 | Wrap up & next meeting date – Wes Davis, Duke (Recommend January 21, 22) |
| 2:30 | ADJOURN |

**Interconnection Technical Standards Review Group (TSRG)**
**Duke Energy Carolinas/Progress**
**Minutes and Attendance**
**September 17, 2019**

## I. Opening

This is a regular meeting called to order at 9:11 AM in Raleigh, NC

Meeting facilitator: Anthony Williams

Minutes: Raven Bowden

## II. Record of Attendance

Member Attendance

| Name | Affiliation | Attendance |
|---|---|---|
| Kevin Chen | Duke Energy | Present |
| Jeff Daugherty | Duke Energy | Absent |
| Wes Davis | Duke Energy | Present |
| Jonathan DeMay | Duke Energy | Present |
| Raven Bowden | Duke Energy Contractor | Present |
| Huimin Li | Duke Energy | Present |
| Orvane Piper | Duke Energy | Absent |
| Bill Quaintance | Duke Energy | Present |
| Jonathon Rhyne | Duke Energy | Present |
| Jim Umbdenstock | Duke Energy | Absent |
| Anthony Williams | Duke Energy | Present |
| Stephen Barkaszi | Duke Energy | Absent |
| Paul Brucke | NCSEA, Sustainable Energy Assoc | Present |
| Jon Burke | GreenGo Energy | Absent |
| James Wolf | Yes Solar Solutions | Absent |
| Jason Epstein | Southern Current | Absent |
| Sean Grier | Duke Energy | Absent |
| Scott Griffith | Duke Energy | Absent |

**Interconnection Technical Standards Review Group (TSRG)**
**Duke Energy Carolinas/Progress**
**Minutes and Attendance**
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| Name | Affiliation | Attendance |
|---|---|---|
| Chuck Ladd | Ecoplexus | Present |
| Bruce Magruder | Keytech Engineering | Absent |
| Luke O'Dea | Cypress Creek | Present |
| Nwene Ogwu | Strata Solar | Phone |
| Chris Sandifer | SCSBA, Solar Business Alliance | Absent |
| Reigh Walling | NCCEBA, Clean Energy Bus Alli | Absent |
| Luke Rogers | Birdseye Renewable Energy | Absent |
| Dawn Hipp | SC Office of Regulatory Staff | Phone |
| Sarah Johnson | SC Office of Regulatory Staff | Absent |
| Robert Lawyer | SC Office of Regulatory Staff | Absent |
| Jay Lucas | NC Public Staff | Absent |
| James McLawhorn | NC Public Staff | Absent |
| Dustin Metz | NC Public Staff | Present |
| Tommy Williamson | NC Public Staff | Present |
| Todd Rouse | Cypress Creek | Absent |
| Max Semerau | Strata Solar | Absent |
| Mike Wallace | Ecoplexus | Absent |

Guest Attendance

| Name | Affiliation | Attendance |
|---|---|---|
| Tom Key | EPRI | Present |
| Cyrus Dastur | Advanced Energy | Present |
| Staci Haggis | Advanced Energy | Present |
| Shawn Fitzpatrick | Advanced Energy | Present |

**Interconnection Technical Standards Review Group (TSRG)**
**Duke Energy Carolinas/Progress**
**Minutes and Attendance**
**September 17, 2019**

## III. Current agenda items and discussion

1) The published agenda was emailed out.
2) May action items – Anthony Williams, Duke
   A) Action Item Response: Duke will ask Protection if leased fiber is an option that is not currently communicated for distribution
      a. Duke Answer: Because of the poor reliability, troubleshooting and O&M issues, continued degradation of 3rd party equipment and service, along with the shorter distances between the station and the site, Duke does not allow the 3rd party fiber for distribution.

   B) Action Item Response: Duke will provide a description of what is done for station-level DTT.
      a. Duke Answer: The combined undervoltage and overvoltage (27/59) protection Duke installs is for the same purpose as 3V0. This protection was used prior to DER installations and one reason it was chosen was that it uses one less CVT than 3V0.
   C) No discussion on Action Items; both issues Closed.

3) PRESENTATION – Sequential Switching Requirements – Anthony Williams, Duke Energy

   A) Presentation provided with minutes
   B) Industry Question – Do you really mean 8 seconds with the plus or minus or 9 or 10?
      a. Duke – Yes, the accuracy of typical timers should fit within the +/- half second. The use of 8 seconds is for sequencing and for modeling. If you allow for 8 seconds and you are switching manually the inrush should be gone before that time.
   C) Industry Question – Is 8 the current standard or is 10?
      a. Duke –The current standard is 10 seconds.
   D) Industry Question – Is the description of the sequential switching needed during the commission phase or before?
      a. Duke – Before the commissioning. Add to the one line. A simple preliminary description of your switching should be fine. Later a final description can be submitted for Advanced Energy to use at commissioning.

   E) Industry Question – If only utility owned recloser, and no need of a site recloser, it would make sense for the first block to not be switched. Would it be acceptable for the first block to not be switched?

      a. Duke – Yes. The requirements were written to be consistent with past guidance that one block could energize when the site was returned to

**Interconnection Technical Standards Review Group (TSRG)**
**Duke Energy Carolinas/Progress**
**Minutes and Attendance**
**September 17, 2019**

service (either by the utility or customer recloser closing). That configuration is allowed, as in the past, but it is not the preferred configuration for Duke. Duke prefers and recommends a delay between energizing the site and connecting the first block, but it is not a requirement.

F) Duke comment – Duke is ready to implement 8 seconds now with 90 days to incorporate the design. If commissioning has begun the design has already been submitted. The intent was the initial design phase. Duke is fine with this going forward in January 2020.

G) Industry Question – Do you mean any project that is already using 10 seconds will remain with 10 seconds as the standard?

b. Duke – Yes, this is a future requirement and not in effect yet. There is no requirement for designs to go back and change.

H) Industry Question – If the projects do start picking up the new standard during commissioning phase would that be fine? At what particular point will Duke enforce this?

c. Duke – Duke expects projects that already use 10 seconds to continue using 10 seconds. As of today 8 seconds is not official. It is fine to use 8 or 10 seconds at the moment until January 2020 when the designs will follow the new standard.

I) Industry Question – should we move the older projects from 10 seconds to 8 seconds to make all site homogenous

d. Duke – There is nothing in the plan at the moment to make timers homogenous. If DER rich feeders are causing issues already we can always work with the owner to change those already. For now, the plan is to wait for an issue before changing an existing site.

J) Industry Question – Alternate Inrush solutions are still allowed?

e. Duke – Yes, those are still allowed.

<u>**K) ACTION ITEM** – Duke will publish the requirements and clarify the transition period between the existing and revised requirements for sequential switching.</u>

4) PRESENTATION – Report on FT and SR process – Tom Key, EPRI

A) Presentation provided with minutes
B) Industry Question – Is IEEE Std. 1547 more applicable to developer or to utility? The standard is not written to say “the utility shall”
   a. EPRI – EPRI believes it is applicable to both as it will affect power quality, feeder reliability, and penetration which is on the utility level.

**Interconnection Technical Standards Review Group (TSRG)**
**Duke Energy Carolinas/Progress**
**Minutes and Attendance**
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C) Industry Question – Will EPRI's report clarify what is recommended for RVC if what is currently done is not recommended?
   a. EPRI – Yes, EPRI will clarify for RVC measurement that we prefer versus what is done now.
D) Industry Question – Are you making a recommendation on the size of kV line that can be used by North Carolina and Fast Track?
   a. EPRI – EPRI is not making a recommendation as this is a standard given by FERC.
   b. Duke – There are few applications for 5 kV lines. It is very minimal in North Carolina, and only in the DEC area.
E) Industry Question – Was any comparison done between the different states with processing applications?
   a. EPRI – Yes, comparisons were done in states such as California and New York.
F) Concerning Fast Track (FT) Screening
   a. Industry Question – What is being defined as the upstream device?
      i. EPRI – EPRI Reviewed two cases of using protective devices or another device where we look to see where the load is and make a recommendation. Green line [on the slide] is the recommendation concerning the device to omit.
      ii. Duke Comments – Duke's concern is that if you move what the upstream device is, the green line, is that you can accidentally create an unanalyzed islanding situation.
   b. Industry Question – Is the 15% screen not only concerned with islanding?
      i. Duke – The 15% is a screen used for more than islanding. For instance, voltage and power quality.
   c. Industry Question – Is there data available that if a process failed FT screening did they get any mitigation options?
      i. EPRI – EPRI has looked at a variety of data of other jurisdictions especially New York where failure is 95%. Specifically, for Duke we have not looked at that.
      ii. Industry Comment – The industry should have data to see which screen failed, and if/when the process goes on did they receive mitigation option.
         1. Duke comment – Most projects go on to pass Supplemental review anyways. Only 11% of projects that go to Fast Track end up in SIS.
   d. Industry Question – Could the projects that fail a particular FT screen be monitored and note the screen and if an upgrade or mitigation was required?
      i. Duke – This is one of or similar to one of the proposed EPRI recommendations. Duke will assess these after they become final.

**Interconnection Technical Standards Review Group (TSRG)**
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**September 17, 2019**

G) Industry Question – What is EPRI's recommendation on Grounding using load threshold?
   a. EPRI – Load threshold guarantees you don't go over the rating of the lightning arrester. EPRI is testing some models on why some utilities do grounding and others do not. EPRI is recommending a change to Duke's policy to include load with the grounding.

H) Industry Question – Is the stiffness ratio of 25 applicable to NC?
   a. EPRI comment – The stiffness ratio of 25 is applicable for aggregate screens. EPRI can then recommend a RVC inrush requirement of 10% instead of 3%.
   b. Duke comment – We have seen power quality worsen on feeders that are DER rich when larger RVC values are allowed.

I) Industry Question – Could the Industry see EPRI's comments on the voltage regulators?
   a. EPRI- possibly there could be an exception for smaller DER.
   b. Industry Comment – Not allowing connections downstream of a LVR is not a result of regulator tap changes increasing as a result of the DER.
      i. Duke comment – Correct. It is because of DSDR which makes Duke unique compared to other utilities. DEC will include a version of DSDR called IVVC.
   c. EPRI will consider Duke's unique Demand Response systems in the report.

J) Duke – EPRI's report will go to the commission in two weeks. Duke will work with the commission on what was discussed in the report. Duke will consider changes as long as power quality and reliably are not affected.

5) PRESENTATION – Pilot Inspection Results for DER sites operating prior to commissioning tests - Kevin Chen, Duke Energy & Cyrus Dastur, Advanced Energy

A) Presentation provided with minutes.

B) Industry Question – If issues were found with the sites were they shut down?
   a. Advanced Energy comment – Sites have not been shut down as a result of inspections. However, one site was taken offline to make the site safe.

C) Industry Question – What is the issue with transformer not being secured to the pad?
   a. Advanced Energy Comment – One is a safety code requirement concerning seismic conditions. Also, under certain fault condition torque can cause movement. Sites have also flooded before and it is unclear that devices would be contained within the site under those conditions. Duke Energy standards require fastening to the foundation as well.

D) Industry Question – What is the projected sampling for next year?
   a. Advanced Energy Comment – Advanced Energy has not decided on sampling size.

**Interconnection Technical Standards Review Group (TSRG)**
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E) Industry Question – How did you alert these developers on inspections?
   a. Advanced Energy Comment – The developers were given a letter by the account managers that they had been selected for inspection in the future.

F) Industry Question – Is Duke Energy looking to implement unannounced inspections?
   a. Advanced Energy – Advanced Energy has not discussed this with Duke.
   b. Duke Comment – Unannounced inspections have not been considered. Duke has considered ways to economically inspect these sites.

G) Duke Question – If the developers were given the ability to perform a self-inspection what would that look like?
   a. Industry comment – It depends on the developer. One consideration is the use of 3rd party contractors to do the inspection for us.
   b. Industry comment – Given an inspection checklist this could be put in the O&M program.
   c. Industry comment – The industry can provide inverter setpoints to Advanced Energy easily that do not require a site visit.

H) Industry Question – What would happen with the results of these reports? Is the industry required to do anything?
   a. Advanced Energy Comment – That has yet to be determined.
   b. Duke Comment– This is a pilot program to see how to economically inspect sites, and address reliability and safety issues. The issues will determine if corrective actions are required.

I) Duke Comments – Duke internally discussed end of the year. The more data received from Industry the more Duke Energy is able to plan for inspections.

J) Industry Questions – So, the weather requirement. If the developer chooses December 29, but cannot do an inspection due to weather requirements can they not get inspected before the end of the year?
   a. Advanced Energy – This is why Advanced Energy is asking for inspections to be done earlier.

K) Industry Question – Any updates on Transmission commissioning inspections?
   a. Duke – No updates on that yet.

L) <u>Industry members discussed possibly integrating/creating a self-inspection program that uses some of the existing O&M checks/tasks that are performed at the site.</u>

6) Wrap up & next meeting date
   A) It was noted that Battery Storage was suggested as a topic but it was not discussed today because those most knowledgeable were on vacation or unavailable.
   B) Duke is conducting a study on smart inverter functionality related to volt-VAR control. The study will evaluate the ability to control voltage and the impacts to

the feeder, station, and transmission system. Following the study, possibly by mid next year, a smart inverter pilot could begin and evaluate impact in the field.

## IV. Next Meeting Date

The group tentatively selected January 21, 2020 for the next meeting.

## V. Closing

The meeting adjourned at 2:13 PM

## VI. Attachments

1) Agenda, “TSRG Agenda 2019_0917, Rev 0.pdf”
2) Presentations:
    a. Sequential Switching Requirements, “Sequential Switching Requirements, Rev1.pdf”
    b. Report on FT and SR Process, “Duke Energy TSRG Meeting (EPRI) - 09-2019 vfinal.pdf”
    c. Pilot Inspection Results for DER sites operating prior to commissioning tests, “TSRG Advanced Energy Presentation Final - 2019-09-17.pdf”

ATTACHMENT C



# Proposed Sequential Switching Requirements

Anthony C Williams
Principal Engineer, DER Technical Standards
DEC/DEP Interconnection Technical Standards Review Group - Raleigh, NC
September 17, 2019

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## Overview

- Background
  - Sequential energization of transformers or blocks of transformers is a way to reduce the simultaneous inrush current and RVC
- Proposal
  - Document the sequential switching requirements in one place
  - Consider configurations not originally postulated: customer-owned reclosers
- Implementation date
- Discussion

## General and Timing Requirements

1. The control system may be ***based on several designs*** including, but not limited to, SCADA, Automated Controller, Power Plant Controller, PLC, or relays. The controls should reliably stagger or sequence transformer energization in blocks. The control system shall autonomously execute switching each block and not rely on a manual implementation.
2. Transformer switching devices shall be rated for the service and capable of being ***opened and closed automatically*** by a control signal.
3. A switching block may contain ***one or more*** transformers. Based on inrush analysis, the Utility shall specify the ***switching block size*** that meets the RVC requirements for each site.
4. There shall be a definite time delay of ***8 seconds*** between each switching block. Commissioning tests will verify the time delay is set to 8 seconds and the actual delay (measured) is 8 ±0.5 seconds.

## Customer Recloser Requirements

5. The initiation and conclusion of the timing sequence varies based on site design.
   a. **Utility-owned recloser only** – All switching block time delays shall start upon the closing of the utility recloser (no intentional delay) or the customer may choose to wait 8 seconds following the closing of the utility recloser to start switching. The last transformer shall be energized within 85 seconds of closing the utility recloser.
   b. **Utility-owned recloser and a customer-owned recloser** – All switching block time delays shall start upon the closing of the customer recloser (no intentional delay) or the customer may choose to wait 8 seconds following the closing of the utility recloser to start switching. The last transformer shall be energized within 85 seconds of closing the customer recloser.
6. If there is a customer-owned recloser it shall close at ***one of the following definite time delays*** following the closing of the utility recloser:
   a. 0 seconds (no intentional delay), or
   b. 8 seconds, or
   c. 5 minutes

   If there are multiple customer reclosers, then the closing of each shall be staggered every 30 seconds.

## Manual Switching Requirements

7. During switching evolutions where the utility recloser remained closed, but the site transformers were deenergized, the site shall ***return transformers to service*** by energizing the blocks ***sequentially***.
8. During ***manual switching*** evolutions, at least ***8 seconds*** shall be maintained between energization events. Blocks energized manually shall be ***no larger than*** the blocks during automatic sequential switching.
9. While not a requirement, Duke recommends energizing all transformers that will be placed in service when the ***site is not generating power***. Energizing transformers while the site is generating could cause protective functions to open the utility recloser.
10. Upon de-energization of the Area EPS or opening the utility or customer recloser, the onsite power system shall automatically configure itself such that it is ***not possible to energize more than one block upon re-energization*** at the PCC. This requirement applies when the sequential switching control scheme is in service (automatic), or when out of service, or in a manual mode

## Documentation and Testing Requirements

11. There shall be a **brief written description** of the scheme concerning how all the requirements are met. The description shall include the type of controller providing the sequencing, sequence of operation, how the scheme only allows one block to energize when the site energizes with the control scheme in service or out of service, devices under control, electrical or mechanical interlocks or permissives incorporated, location of any sensing devices, number of switching blocks, nominal duration of the time delay, and the total time to energize all blocks. Based on the complexity of the description, Duke Energy may determine that logic or one-line schematics are required for clarity and shall be provided..
12. Use of a sequential switching scheme shall be **noted on the oneline** at each device controlled by the scheme.
13. The sequential switching scheme description, design, and configuration shall be submitted to and ***approved by Duke Energy*** based on these requirements.
14. The sequential switching scheme design, configuration, and operation shall be verified and tested during ***commissioning***.

# Conclusion

- Implementation date
  - Designs submitted 90 days following the TSRG

- Discussion

ATTACHMENT C

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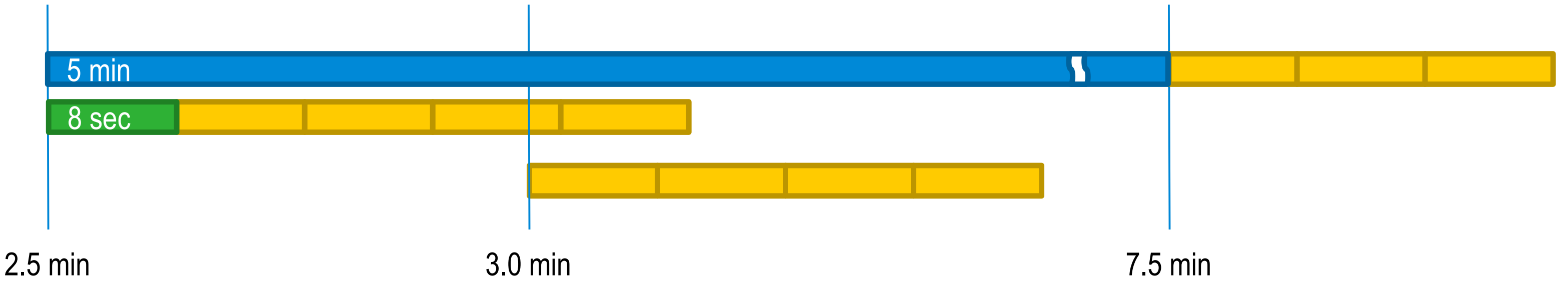
ATTACHMENT C

# Timing Illustrations

3 blocks - 2.5 minutes Duke, 5 min customer, 8sec, 8sec, 8sec
4 blocks - 2.5 minutes Duke, 8sec customer, 8sec, 8sec, 8sec , 8sec
4 blocks - 3.0 min Duke, no customer recloser, 8sec, 8sec, 8sec, 8sec



ATTACHMENT D

# Duke Energy's Fast Track and Supplemental Review Process

## Independent 3rd-Party Evaluation

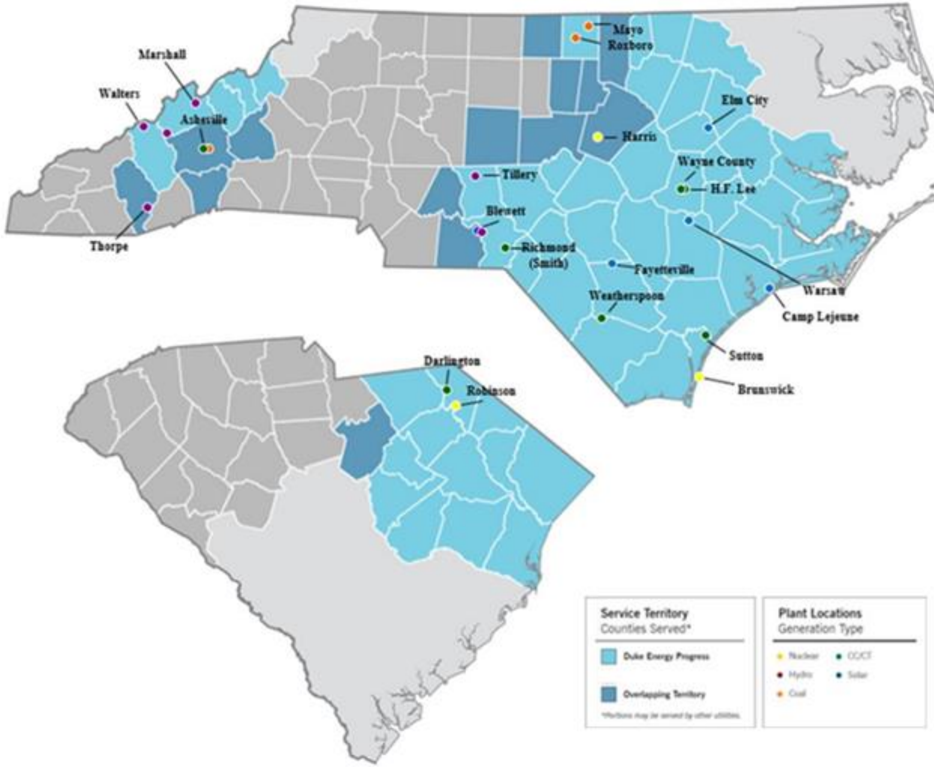
Tom Key, Senior Technical Executive
The Electric Power Research Institute (EPRI)

Technical Standards Review Group (TSRG) Meeting
September 17, 2019

# Project Background

- This effort is intended to meet the following stipulation of the NC Public Staff in Docket No. E-100, Sub 101:

  *Duke will consult with EPRI "regarding any potential modifications to the Fast Track and Supplemental Review process. DEC and DEP will commence such process no later than April 1, 2019 and will provide a summary report regarding any potential modifications at the Technical Standards Review Group meeting occurring in the third quarter of 2019." To address this stipulation EPRI will provide evaluation of Duke Energy's interconnection.*



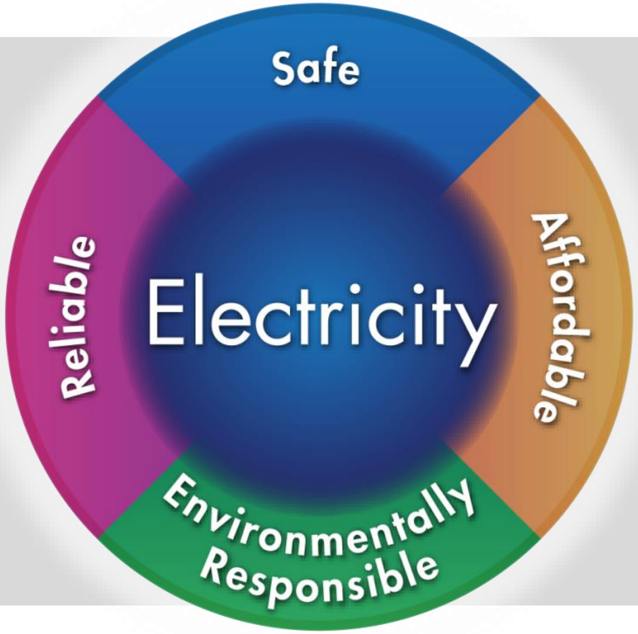

- EPRI review complete
- Preliminary findings provided to NCUC on Aug. 27th
- Results to be presented at Sep. 17th TSRG meeting
- Final report to Commission by end-Sep.

# Biographical Information: Thomas Key

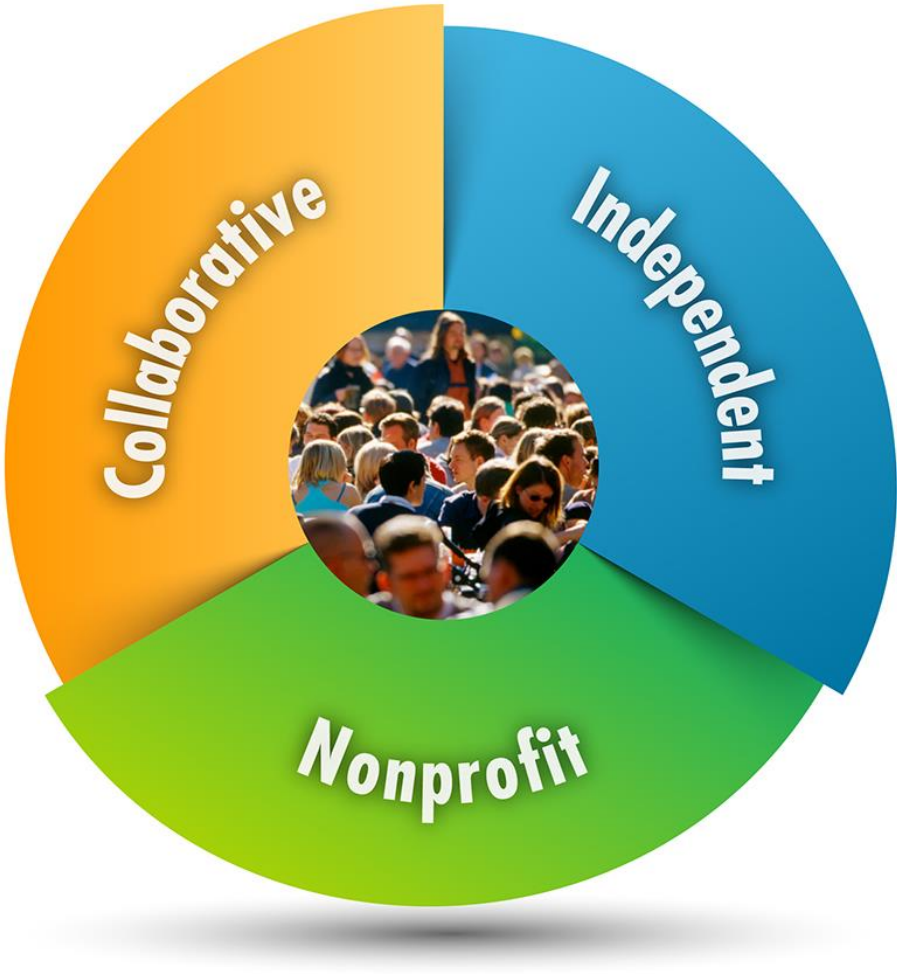
- Tom Key is a Senior Technical Executive at EPRI in the area of electric power delivery and end-use. He has been engaged in power system engineering and research for over 49 years.
- His experience is in distributed power system grid integration and power electronics, such as smart inverters for solar photovoltaics (PV). He also specializes in power quality for utility systems.
- He is a *fellow of the IEEE* for his contributions in grid system compatibility and power quality, and a recipient of the IEEE Power and Energy Society's Award for Renewable Energy Excellence for pioneering contributions in development and integration of renewable energy.
- Beyond EPRI, Tom's career includes positions with the U.S. Navy Seabees and Sandia National Laboratories.
- He is a recipient of EPRI's lifetime achievement award.

# EPRI's Mission

Advancing ***safe***, ***reliable***, ***affordable*** and ***environmentally responsible*** electricity for society through global collaboration, thought leadership and science & technology innovation



# Three Key Aspects of EPRI




## Independent

Objective, scientifically based results address reliability, efficiency, affordability, health, safety, and the environment

## Nonprofit

Chartered to serve the public benefit

## Collaborative

Bring together scientists, engineers, academic researchers, and industry experts

# Agenda

- Project objectives and EPRI background
- Benchmark: NCIP and Duke practices
- Summary: EPRI review, commentary, and recommendations
  - Fast Track Eligibility
  - Fast Track Screens
  - Supplemental Review
- Review Details, Technical Discussions
- Q&A and any next steps

*Open discussion (throughout)*

# Approach to Task

- Reviewed Duke's DER connection process with focus on Fast Track technical screening and supplemental review
- Compared technical details with related integration experience from other utilities and jurisdictions, FERC SGIP and IEEE Std 1547
- Met with Duke Energy technical staff to understand and assess Fast Track eligibility, screens, and supplemental review

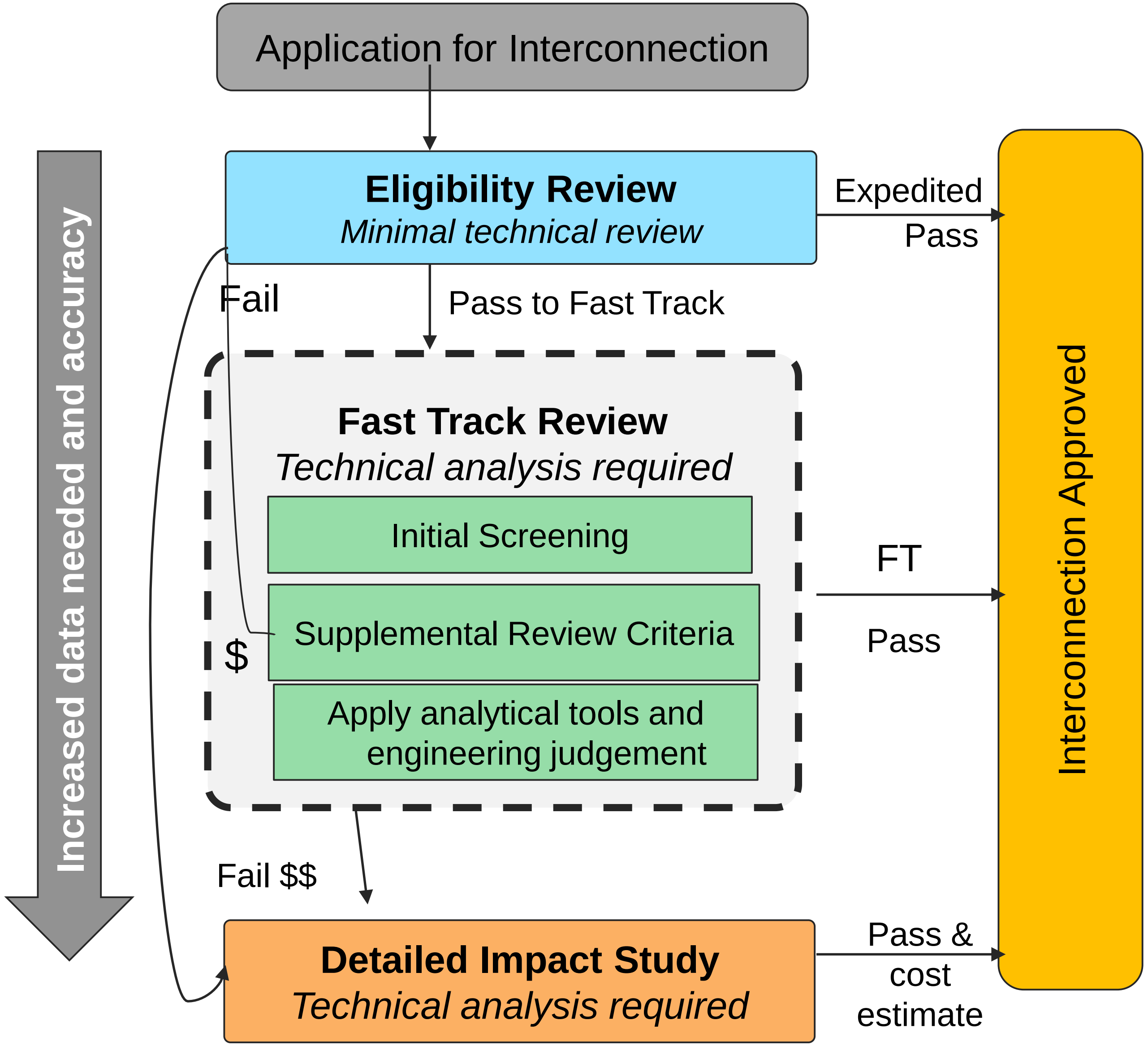
- Scope of Fast Track (FT) Technical Reviews:
  - FT Eligibility
  - FT Screening: 10 screens from NCIP E-100 (2019), and their application
  - FT Supplemental Review: from NCIP and Duke's current criteria/tests

# The Art of Screening… There Is No Perfect Way

- A wide range of DER technical review processes are in use today.
- Most processes with variations have review levels and a Fast Track
- Variables in addition to region and jurisdiction
  - Application volume
  - Penetration levels
  - Deployment history
  - Interconnection review experience/learning curve
  - Predominance of system sizes (related to incentive)
  - Vintage and type of DER

# Technical Review Fast Track Practices




## Types of Review Criteria

- Basic eligibility
- Protection
- Export limits
- Capacity Limits
- Voltage
- Thermal
- Power Quality
- Reliability

# Examples of the "Art" of Screening/Fast Track

- No one best way to exactly conduct Fast Track Technical Review
- SGIP is broadly applied, but is not a standard. Initially used for transmission.

- **New York Standardized Interconnection Requirements (NY SIR):**
  - In 2017: 96% of apps expedited (20% of DER capacity), 4% (80% of capacity) screened; if failing, then optional - supplemental review (was seldom used) or study.
- **California Electric Rule 21 (Rule 21):**
  - May opt for FT or detailed study; screens consider if NEM (with/without export). Every eligible application is screened. No "expedited" process in CA.
  - 9-13 screens used depending on project. Apps that fail screens go to SR (popular, in contrast to NY); SCE and PG&E (which process ~40k-50k apps/year) connect many via SR.
- **Minnesota Distributed Energy Resources Interconnection Process (MN DIP):**
  - Recently applied a modified SGIP. Process is slightly different than NY (and NC), also different than CA (and NC) in that screens don't depend on tariffs and plant size.

# Example Differences: SGIP and MN DIP

## FERC SGIP

- *3.1 Applicability*
  - *The Study Process shall be used by an Interconnection Customer proposing to interconnect its Small Generating Facility with the Transmission Provider's Transmission System or Distribution System if the Small Generating Facility:*
    - *(1) is larger than 2 MW but no larger than 20 MW,*
    - *(2) is not certified, or*
    - *(3) is certified but did not pass the Fast Track Process or the 10 kW Inverter Process.*

## MN DIP

- *1.1 Applicability*
  - 1.1.1 The MN DIP applies to any DER no larger than 10 MW interconnecting to, and operating in parallel with, an Area EPS distribution system in Minnesota.
    - ✓ 1.1.1.1 An application to interconnect a certified, inverter-based DER no larger than 20 kW shall be evaluated under the Section 2 Simplified Process.
    - ✓ 1.1.1.2 An application to interconnect a DER shall be evaluated under the Section 3 Fast Track Process if it meets the eligibility requirements of Section 3.1. An application to interconnect a DER that does not meet the Simplified Process or Fast Track Process eligibility requirements, or does not pass the review as described in either process, shall be evaluated under the Study Process.
    - ✓ 1.1.1.4 Prior to submitting an Interconnection Application, the Interconnection Customer may ask the Area EPS Operator's Interconnection Coordinator whether the proposed interconnection is subject to these procedures.

ATTACHMENT D



# Review: Comparison to Industry Practices

| Specific Technical Issue | Type of Review | NC E-100 Screens | Duke's Current Practice | Industry Norms | EPRI Observation Duke/Industry | Review Type/Level | Applies to DER | IEEE 1547-2018 Reference |
|---|---|---|---|---|---|---|---|---|
| **Screening not required** | Basic | **3** | <20 kW | <10 to 50kW | **Within Industry norm** | Preliminary | Individual | |
| **Certification required** | Basic | **3** | Yes | Yes | **Same practice** | Fast Track | Individual | 11.1-4 |
| **Monitoring capacity** | Basic | **3** | Yes | Yes | **Same practice** | UL Tested | Individual | 10 |
| **Relative size concern** | Basic | **3.1.1** | Preapprove SR | Options Vary | **May save process time** | Supplemental | Individual | 4.6.2 |
| **Qualifies for Fast Track** | Basic | **3.1-table** | Per NC kW/kV class | Per SGIP | **More conservative** | Preliminary | Individual | |
| **Confirm service availability** | Basic | **3.2.1.1** | Yes | Yes | **Same practice** | Fast Track | Individual | |
| **Unintended islanding % peak** | Protection | **3.2.1.2** | 15% | 15% or min. | **Opportunity to clarify** | Fast Track | Aggregate | 8.1 |
| **Unintended islanding % min** | Protection | **3.2.1.3** | 90% in FT | 100% in SR | **Within Industry norms** | FT or SR | Aggregate | 8.1 |
| **On spot or LV network** | Basic | **3.2.1.4** | 5% | 5% or 50 kW | **Within Industry norms** | Fast Track | Individual | 9.2 and 9.3 |
| **Short circuit contribution** | Protection | **3.2.1.5** | 90% /10% | 90%/10% | **Same practice** | Fast Track | Aggregate | 11.4 |
| **Interrupting capability** | Protection | **3.2.1.6** | 87.5% Limit | 87.5% limit | **Within Industry norms** | Fast Track | Aggregate | 6.2. |
| **GFO/effective grounding** | Protection | **3.2.1.7** | Inverter exception | Varies | **Recommended practice** | Fast Track | Individual | 4.12 |
| **Exceeds secondary ratings** | Thermal | **3.2.1.8** | 65% | 20kW 65% | **Within Industry norm** | Fast Track | Aggregate | |
| **Secondary imbalance** | Voltage | **3.2.1.9** | 20% | 20% | **Same practice** | Fast Track | Individual | |
| **Transient stability** | Penetration | **3.2.1.10** | depends on HV | 10 MW limit | **Within Industry norms** | Fast Track | Aggregate | |
| **Safety/Reliability** | Penetration | **3.2.2.4-6** | Six tests | Tests Vary | **Better defined than norm** | Supplemental | Aggregate | 4.6.2 |
| **Flicker** | PQ | **3.2.2.4-6** | By exception | Pst <.35 | **Recommended practice** | Supplemental | Individual | 7.2 |
| **Rapid Voltage Change** | PQ | **3.2.2.4-6** | MV 3% ΔVpeak | MV-3%/second | **Conservative inrush test** | Supplemental | Individual | 7.2 |
| **Aggregate RVC Limit** | PQ | **3.2.2.4-6** | MV 4% ΔV | Not used | **Not a recommended test** | Supplemental | Aggregate | 7.2 and appendix E |
| **Harmonics** | PQ | **3.2.2.4-6** | By exception | $I_{THD}$<5% | **Within Industry norm** | UL Tested | Individual | 7.3 |
| **Stiffness at PCC** | Voltage / PQ | **3.2.2.4-6** | >25 times | 20 - 50 | **Recommended practice** | Supplemental | Individual | |



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# Summary: EPRI Review of NC Fast Track (FT) Eligibility (NC E-100 Section 3.1)

| Technical Consideration & Criteria | NC E-100 Section | Review Type/ Level | Observation[1] | Recommendations and Next Steps[2] |
|---|---|---|---|---|
| **Expedited process, limited screening ≤ 20kW** | **3.1** | FT Eligibility | Expedited interconnection for small, typically residential, PV has become widely accepted practice. The expedited range is ~ 10-50kW for certified inverter DER connections (not addressed in current FERC-SGIP). | None |
| **Certified inverters only** | **3.1** | FT Eligibility | Certification is a key requirement in FT, both screens and supplemental review depend of it. Non-inverter certification is possible and may require future changes to FT processes. | None |
| **FT Eligibility, kW level for feeder kV level** | **3.1-table** | FT Eligibility | NC is currently more conservative on FT size eligibility than is recommended in FERC-SGIP. It is not clear that changing eligibility limits would enhance interconnection process in NC (~10 projects/year, 85% of 5kV within 2.5 mi.). | Periodically monitor if applications that are not FT-qualified are connected without mitigations. Consider if more experience and better tools will address larger DER. |
| **Pre-authorize Supplemental Review** | **3.1.1** | FT Eligibility | Pre-authorization for supplemental review looks like a practical time saving option. Data support the practice. | Continue to evaluate supplemental review criteria. Consider success rate with/without supplemental review. |

*Notes: 1 – EPRI examined 52 technical review considerations and criteria in nine different jurisdictions including FERC SGIP and IEEE 1547.*
*2 – EPRI recommendations based on red-line updates to NC E-100, proposed clarifications and new supplemental review criteria.*

  

*Detailed Findings – Eligibility for FT*

# DER kW Eligibility by Feeder kV Level (3.1)

## NCIP Table 3.1 (2015)

| Fast Track Eligibility for Inverter-Based Systems[1] | | |
|---|---|---|
| Line VMoltage | Fast Track Eligibility Regardless of Location | Fast Track Eligibility on a Mainline[2] and ≤ 2.5 Electrical Circuit Miles from Substation[3] |
| < 5 kV | ≤ 100 kW | ≤ 500 kW |
| ≥ 5 kV and < 15 kV | ≤ 1 MW | ≤ 2 MW |
| ≥ 15 kV and < 35 kV | ≤ 2 MW | ≤ 2 MW |

## SGIP (2016)

| Fast Track Eligibility for Inverter-Based Systems | | |
|---|---|---|
| Line Voltage | Fast Track Eligibility Regardless of Location | Fast Track Eligibility on a Mainline1 and ≤ 2.5 Electrical Circuit Miles from Substation2 |
| < 5 kV | ≤ 500 kW | ≤ 500 kW |
| ≥ 5 kV and < 15 kV | ≤ 2 MW | ≤ 3 MW |
| ≥ 15 kV and < 30 kV | ≤ 3 MW | ≤ 4 MW |
| ≥ 30 kV and ≤ 69 kV | ≤ 4 MW | ≤ 5 MW |

- **Discussion**
  - Duke complies with the NCIP kW size limits (no 69kV distribution, 44kV transmission)
  - Differences between SGIP and NCIP limits are in the eligible kW ratings/voltage level
  - In case of 5kV, 85% of circuit miles are less than 3 miles long
- **Suggested Next Step**
  - Periodically monitor if any non-qualifying applications are being connected without mitigations (for example at substation, with CSR>25 or well-defined mitigations)

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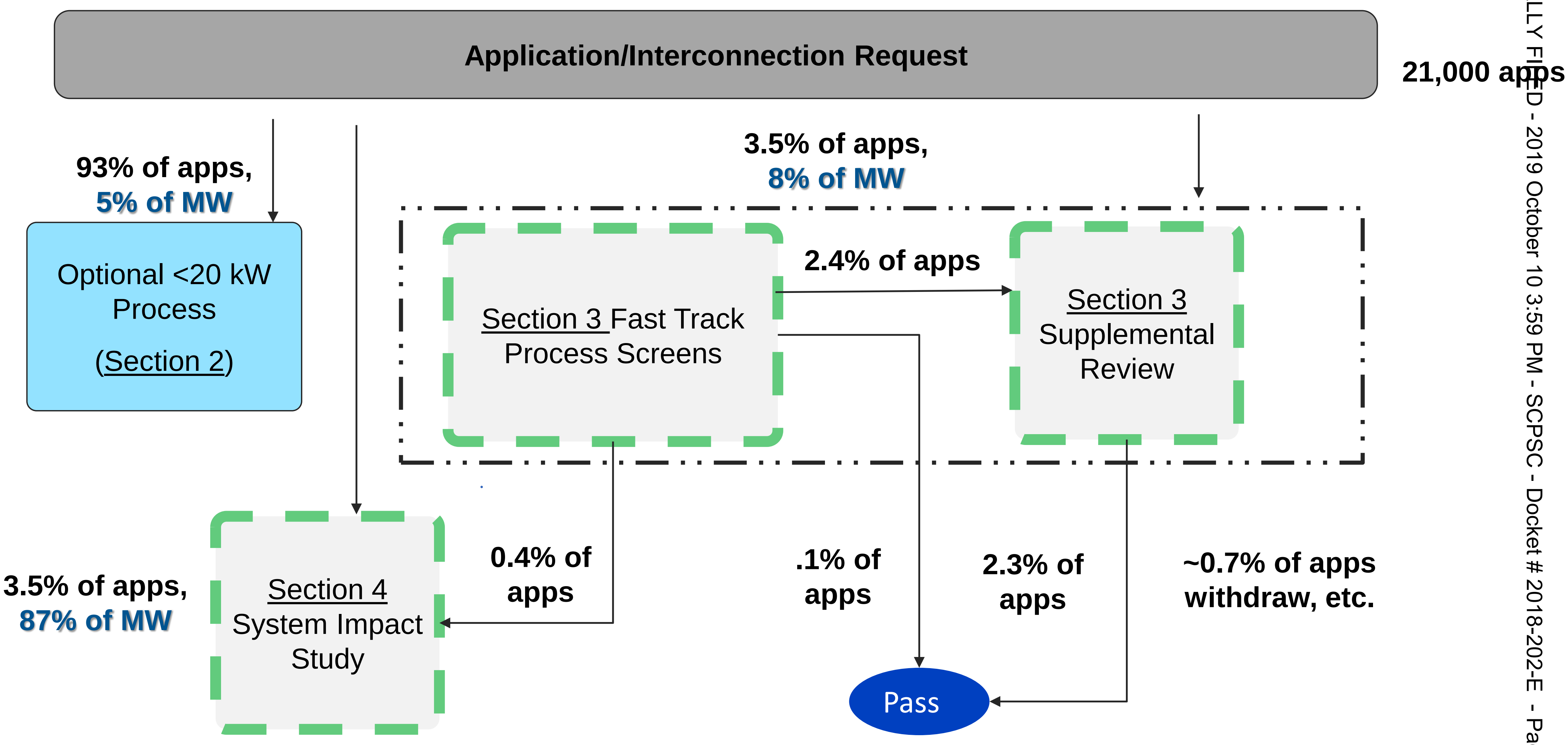
# Interconnection Applications and Fast Track in NC/SC

*Summary of DG applications NC/SC DEP/DEC May 2015- Aug. 2019*



*Detailed Findings – Eligibility*

# Pre-Authorize Supplemental Review (3.1)

- **Discussion**
  - Pre-authorization for SR looks like a practical time saving option.
  - Previous data since 5/15 provides support for this practice.
    - ~20,000 applications <20kW are expedited (21,400 total, NC & SC)
    - 605 of remaining applications qualified for Fast Track
      - 5% connected based on screens.
      - 56% connected based on supplemental review
      - 61% connected, 11% to system impact, 27% withdrawn
- **Suggested Next Steps**
  - Continue to evaluate SR criteria.

# Summary: EPRI Review of FT Screening (NC E-100 Section 3.2)

| Technical Consideration & Criteria | NC E-100 Section | Review Type | Observations[1] | Recommendations and Next Steps[2] |
|---|---|---|---|---|
| **POI location on Duke system** | **3.2.1.1** | Individual | Application PCC to be located in service territory | None |
| **Line section generation is <15% of peak load** | **3.2.1.2** | Aggregate | 15% of peak is used as an estimate for minimum load on line sections. SGIP and a number of jurisdictions with higher penetration of solar use day-time minimum load. | Either estimate or, if known, use daytime minimum load in case of solar PV. |
| **<90% of min load** | **3.2.1.3** | Aggregate | SGIP screens do not address min load. This screen could enhance first level review if the rationale and relationship to 3.2.1.2 are clarified. Indicator of high penetration on feeders. | None |
| **On spot or LV networks** | **3.2.1.4** | Aggregate | Consistent with SGIP, some jurisdictions do not allow network connections based on screening. | None |
| **SC contribution <10%** | **3.2.1.5** | Aggregate | Consistent with SGIP, failure indicates a protection issue | None |
| **Interrupting <87.5%** | **3.2.1.6** | Aggregate | Consistent with SGIP, failure indicates a protection issue | None, see supplemental review |
| **DER effective grounding** | **3.2.1.7** | Individual | Duke uses recommended practice, not clear in SGIP | Modify criteria for inverters in E-100 |
| **Secondary transformer 65%** | **3.2.1.8** | Aggregate | Addresses voltage on shared LV, consistent with SGIP | None |
| **Secondary imbalance 20%** | **3.2.1.9** | Individual | Addresses voltage on shared LV, consistent with SGIP | None |
| **Transient stability limits** | **3.2.1.10** | Aggregate | A transmission-level issue…may not be needed for FT | None |

*Notes: 1 – EPRI examined 52 technical review considerations and criteria in nine different jurisdictions including FERC SGIP and IEEE 1547.*
*2 – EPRI recommendations based on red-line updates to NC E-100, proposed clarifications and new supplemental review criteria.*

*Detailed Findings – Fast Track Screens*

# Line Section Generation is <15% of Peak Load (3.2.1.2)

- **Discussion**
  - 15% of peak is used as an estimate for minimum load on line sections.
  - SGIP and other jurisdictions w/higher penetration of solar have:
    1. Clarified to use day-time minimum load when known, and/or
    2. Considered and applied (higher or lower) instead of 15%.
- **Suggested Next Steps**
  - Use estimate of daytime minimum load in case of solar.
  - Apply exception for next upstream automatic sectionalizing if generator is on a service transformer (see examples).

# EPRI Recommended Changes for 3.2.1.2

## 15% of Peak on Line Segment

- Consider increased aggregate DER limit in cases where the minimum load on the next upstream device is known and is >15% limit.

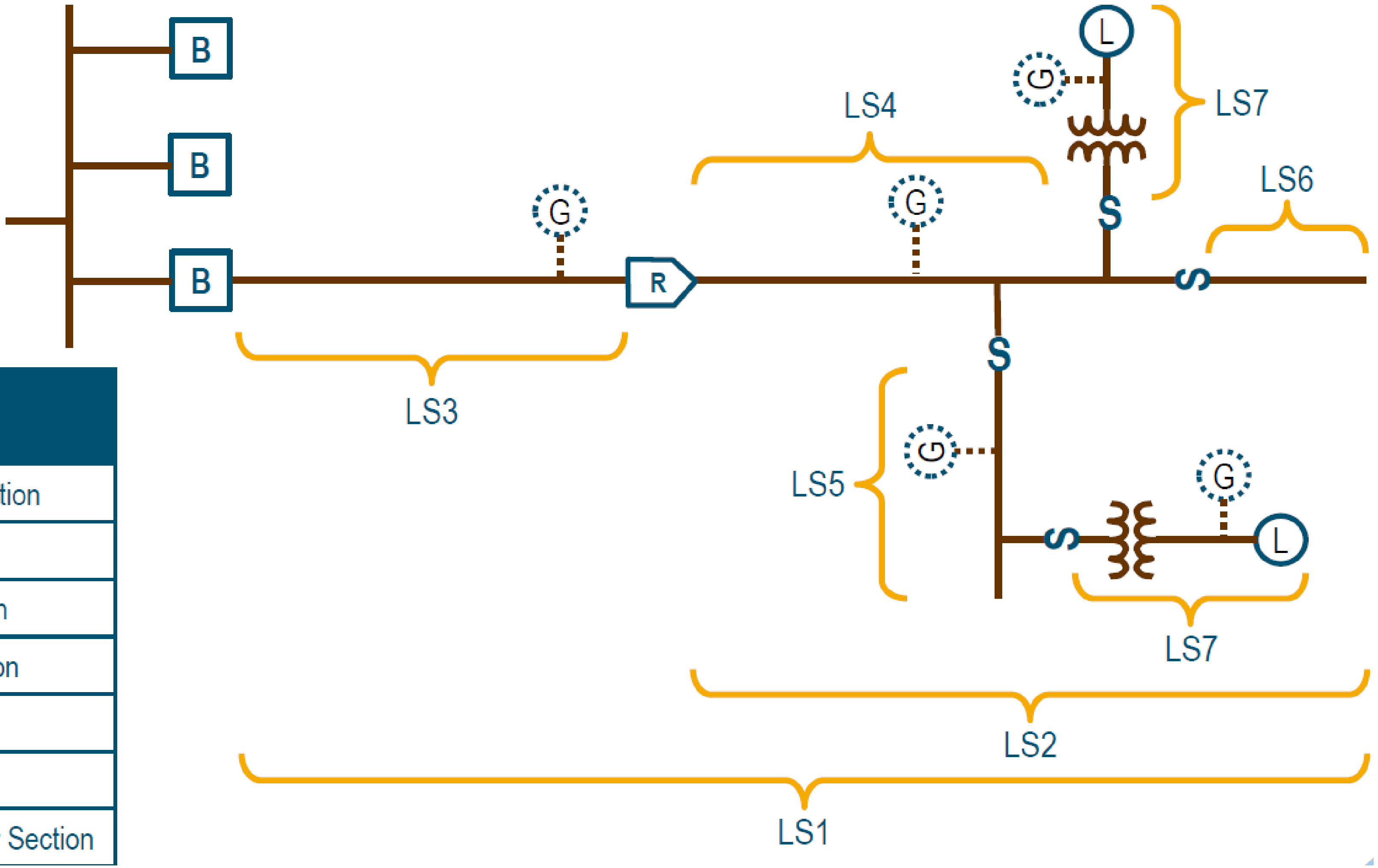
- Clarify application of 15% limit to consider all load on next upstream device and not just the load between two sections.
  - Rationale: Other jurisdictions applying engineering judgement have also proposed clarification of the line section limit. The low probability of isolating a line section with the certified DER remaining on line in a condition of generation and load balance (with the risk of unintended islanding) can be considered as very unlikely and an acceptable risk.

# Definition of Line Sections

*For islanding concerns only the upstream device should be considered defining aggregate DER and load. For example; B is all load and dg on the feeder (LS1), R is all downstream (LS2), fuse S may include one or two line sections.*

- Line sections are defined by the next upstream automatic sectionalizing device and all downstream.

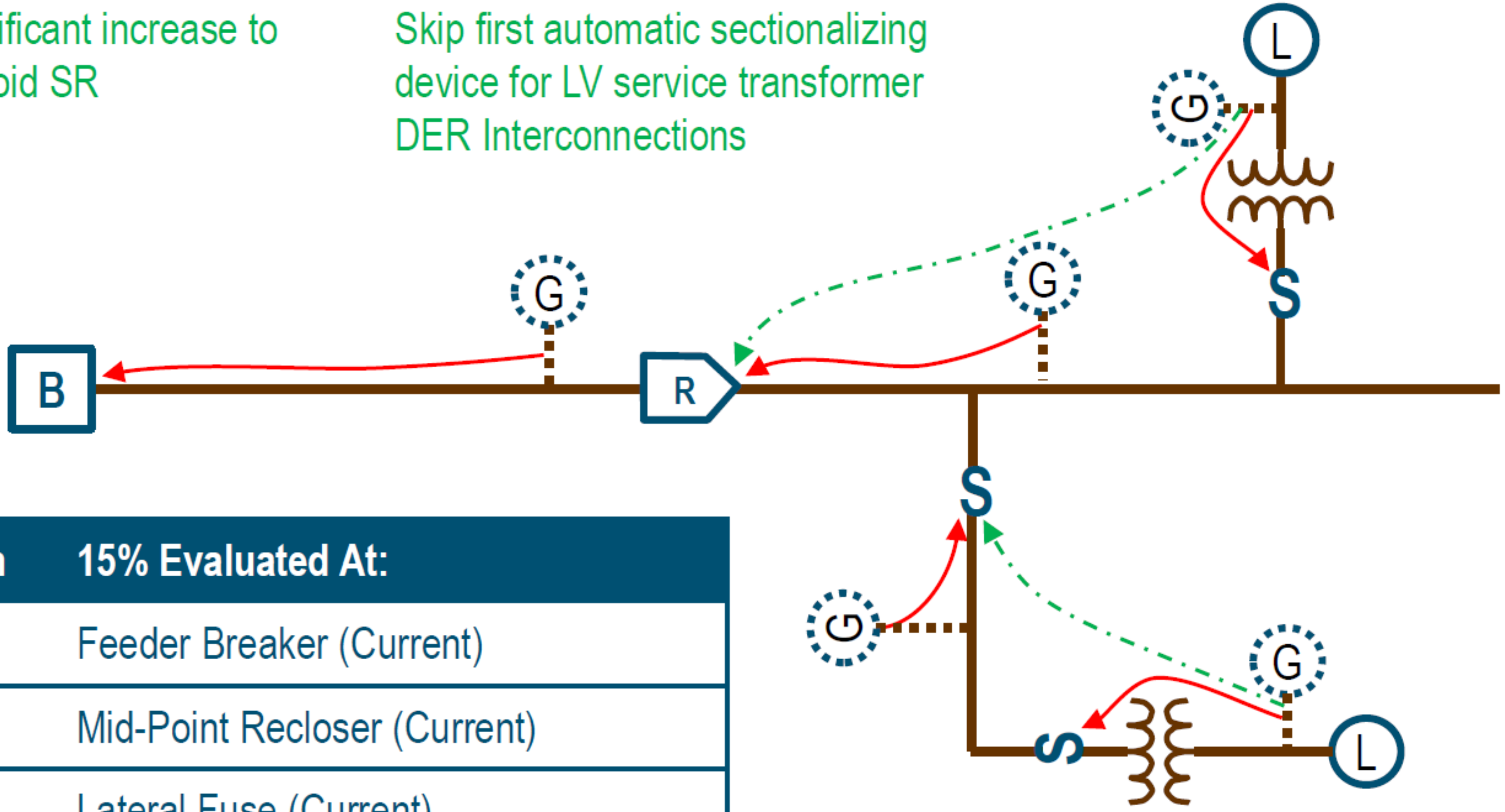
| Line Section | Description |
|---|---|
| LS1 | Feeder Breaker Section |
| LS2 | Recloser Section |
| LS3 | Breaker First Section |
| LS4 | Recloser First Section |
| LS5 | Lateral Section |
| LS6 | EOL Fused Section |
| LS7 | Service Transformer Section |



# Duke Procedure in Case of DER on Secondary

Based on small sample, this change would allow a significant increase to pass in FT and avoid SR

Proposed Alteration
Skip first automatic sectionalizing device for LV service transformer DER Interconnections

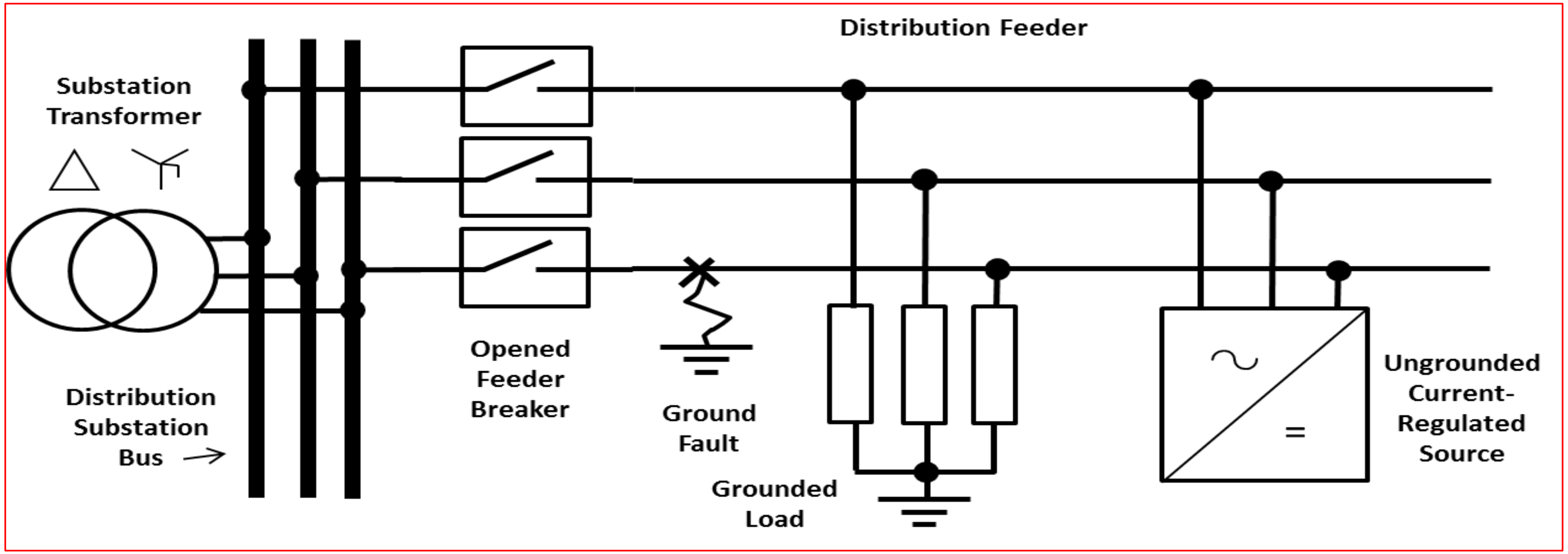



| DER Zone Of Protection | 15% Evaluated At: |
|---|---|
| Feeder Breaker Zone | Feeder Breaker (Current) |
| Mid-Point Recloser Zone | Mid-Point Recloser (Current) |
| Lateral Fuse Zone | Lateral Fuse (Current) |
| Service Transformer Zone | Service Transformer Fuse (Current)<br>Second ASD Upstream (Proposed) |

# DER effective grounding (3.2.1.7)

## DER System Grounding in Unintentional Islanding Scenarios

1. Inverter-based DER are expected to have insignificant effect on system grounding when the feeder breaker is closed
2. The main concern is ground fault overvoltage (GFO) in case DER supports an unintentional island (feeder breaker open) with a ground fault




***GFO is the first order concern in this scenario***

# DER Connection Screening Practice

## Used in FERC-SGIP, NY SIR (screen D), CA Rule 21 (H), NC (screen 7)

- Aim to screen out DER connections prone to ground-fault overvoltage (GFO) and to limit allowed connection types based on concerns for ground fault and open-phase
- Table commonly used (is not appropriate for inverter-based DER)

| Primary Distribution Line Type | Type of Interconnection to Primary Distribution Line | Result/Criteria |
|---|---|---|
| Three-phase, three wire | 3-phase or single phase, phase-to-phase | Pass Screen |
| Three-phase, four wire | Effectively-grounded three-phase or single phase, line-to-neutral | Pass Screen |

- Failing the screen typically leads to alternatives such as adding a grounding transformer

# EPRI Proposed Screen in NY SIR

## Screen D: Is the Line Configuration Compatible with the Interconnection Type?

Identify primary distribution line configuration that will serve the distributed generation or energy storage. Based on the DER interconnection and using the table below, determine compatibility with the electric power service.

| Primary distribution line configuration | Type of DER connection to primary | Result/Criteria |
|---|---|---|
| Three-phase, three-wire | If ungrounded on primary or any type on secondary | Passes this screen |
| Three-phase, four-wire | Single-phase line-to-neutral | Passes this screen |
| Three-phase, four-wire (For any line that has sections or mixed three-wire and four-wire) | All others | Pass for inverter DER, if rating is ≤ feeder min load, or ≤ 30% peak load. Pass for synchronous DER, if rating ≤ 10% of the line-section peak load. |

# EPRI's Recommended Objectives for SR Level Criteria

- *Provide checklist as alternative to system impact studies for applications that fail (or opt out of) NC Fast Track screening*
- *Include in review unique feeder characteristics/tools (voltage load-flow, short circuit coordination, etc.)*
- *Complete relatively fast assessment of needs when apps don't require significant modifications or upgrades*
- *Include off-the-shelf and customary mitigations*
- *Combine pre-defined criteria with field experience and engineering judgement to confirm DER will do no harm.*
- *Aim to limit the required number of detailed studies.*

# Summary of Duke's Proposed SR Criteria

1. **Voltage Regulator Policy** – Refers to line and substation and considers minimum load reduction
2. **Voltage Regulation Limits** – Refers to ANSI C84.2 Range A limits using MV load flow analysis and calculation of service LV
3. **Power Quality Limits** – Refers to IEEE 1547 established PQ criteria for DGs and considering impact on other customers.
4. **Distribution Protection** – Addresses fault current limits and protection coordination and uses short circuit analysis tools.
5. **Substation Available Capacity** – Addresses any limits in power systems capacity to support generation and load.
6. **Unintentional Islanding Risk** – Considers aggregate generation type, configuration, protection, and potential to support load.

# Summary: EPRI Evaluation of Supplemental Review (NC E-100 Section 3.4)

| Technical Consideration and Criteria | NC E-100 Section | Review Type | Observations[1] | Recommendations and Next Steps[2] |
|---|---|---|---|---|
| **Line Voltage Regulator Upstream** | 3.4.1 | Individual | >250 kVA DER downstream of any regulator needs to connect above regulator | Any change would have to consider voltage optimization, regulator device upgrades, other grid modernization and reconfiguration issues. |
| **Voltage Regulation Limits** | 3.4.1 | Aggregate | Steady state voltage review criteria follows expected industry practices | None |
| **Power Quality Reviews** | 3.4.1 | Individual | Relies on IEEE Std 1547-2018 | Note: Stiffness Ratio (CSR) of 25 times is another good test to avoid PQ issues |
| **Flicker – Pst <.3** | 3.4.1 | Individual | Certification is sufficient unless exceptional case is identified | This is a recommended practice |
| **Distortion – $I_{TDD}$ <5%** | 3.4.1 | Individual | Certification is sufficient unless exceptional case is identified | This is a recommended practice. |
| **RVC – $\Delta V_{RMS}$ <3%** | 3.4.1 | Individual | Limits transformer in-rush to a max voltage dip of 3%; this is conservative. | Consider increasing limit to 10-12% for the peak $V_{RMS}$ or use average over 1-2 sec. |
| **Distribution Protection** | 3.4.1 | Individual | Review criteria and rationale follow expected industry practices | None |
| **Substation Available Capacity** | 3.4.1 | Individual | Review criteria and rationale follow expected industry practices | None |
| **Unintentional Islanding** | 3.4.1 | Individual | Review criteria and rationale follow expected industry practices | None |

*Detailed Findings – Supplemental Review*

# 1. Upstream Voltage Regulator (LVRs)

- **Duke Criteria**
  - Does the project comply with the Duke Method of Service Guidelines, section 3.2?
  - Does the addition of the exempt Generating Facility cause back-feed of power through a line-voltage regulator?
  - The review applies to the aggregate generation downstream of all existing and any planned line-voltage regulators. The estimated minimum load is considered as a reduction to potential back-feed. If back-feed is indicated, the Generating Facility fails Supplemental Review and requires additional study.
- **EPRI Rationale**
  - Regulators are usually not configured for back-feed. Changing LVR configuration is typically a major modification requiring detailed review.
  - Duke is looking at future grid modernization and potential of smart inverter (visibility, communication, and control).

*Detailed Findings – Supplemental Review*

# 2. Voltage Regulation Limits

- **Duke Criteria**
  - Is the Generating Facility expected to cause any voltage violations such as exceeding ANSI C84.2 Range A limits?
  - A circuit load flow analysis is conducted to calculate voltage changes on the feeder. Using these results, the service voltage to customers is estimated. If no violations are indicated, the Generating Facility meets the criteria. If the Generating Facility causes violations, then it fails Supplemental Review and requires additional study.
- **EPRI Rationale**
  - Voltage rise is most common outcome of higher penetration of DER, either ANSI limits relative to rated, or relative to moving average is normally considered.
  - Results should inform if any and what specific additional detail reviews are needed.

*Detailed Findings – Supplemental Review*

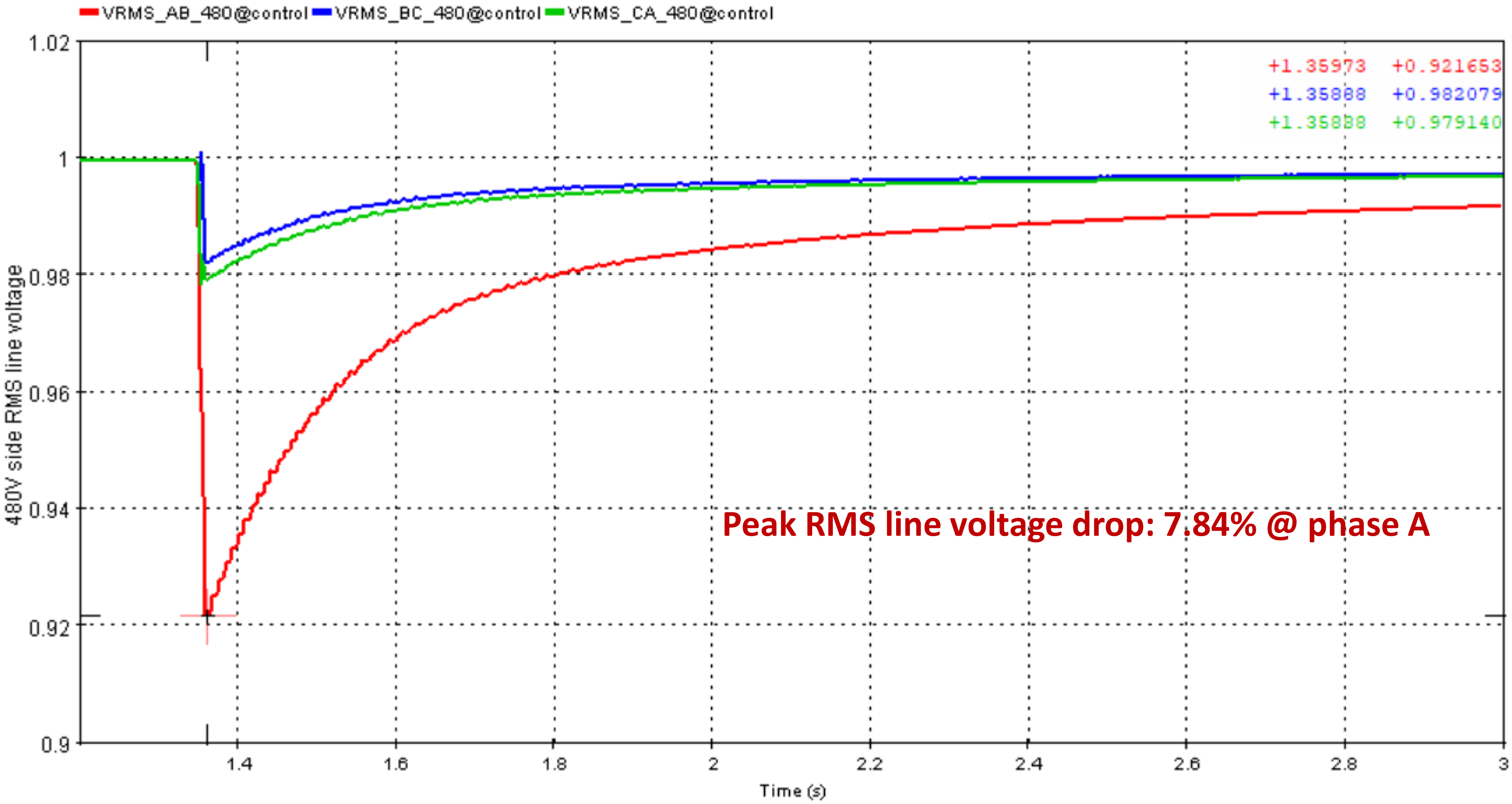
# 3. Power Quality Limits

- **Duke Criteria**
  - Is the Generating Facility expected to cause any power quality limit violations when interconnected?
  - Power quality assessments such as in-rush, RVC, or resonance are performed on the Generating Facility and/or the rest of the circuit; requirements in IEEE 1547-2018 Section 7 are considered. If violations are indicated by addition of the Generating Facility, then it fails Supplemental Review and requires additional study.
- **Rationale**
  - The power quality impact depends mostly on circuit strength at the PCC.
  - Certification verifies DER performance in the lab. Additional review considers plant field conditions and relative size.
  - Note: stiffness ratio is another way to look at potential impacts of PQ. Harmonic, EMC, and other interactions are difficult to predict and therefore contingency options for unforeseen PQ interactions should be included in agreements.

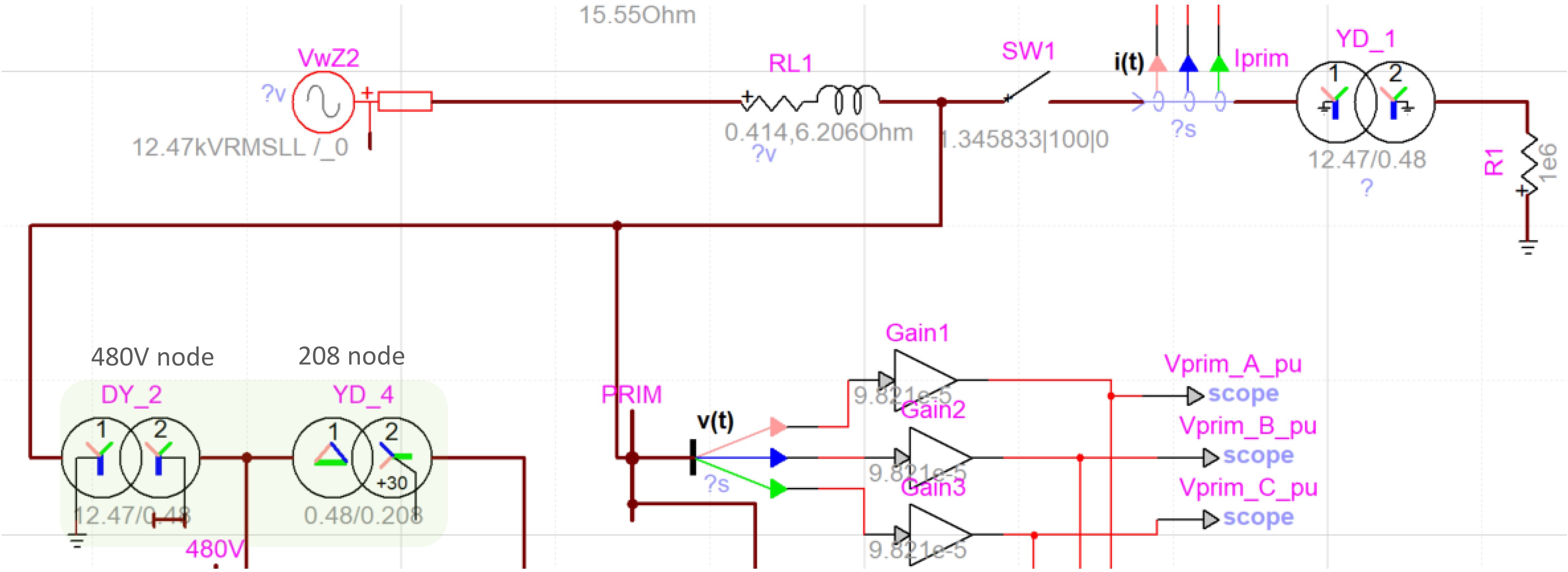
  

# RVC <3% ΔV (3.4.1)

## Inrush transient with CRV of 25 at 480V Side RMS line Voltage



# Large Three-phase Four-wire Commercial and Industrial Customers




- Yg/Y and Δ/Yg transformers are used for12.47 kV/480V and 480V/208V conversion
- No load is connected

Three-phase service may be 120/208V. Some larger commercial and industrial may have 4-wire with 277V lighting, 480V motors and step down for plug loads.

# Summary on RVC Tests

| Peak RMS Voltage drop (% | Primary 12.47kV | | 480V side | | 208V side | |
|---|---|---|---|---|---|---|
| | Phase voltage | L-L voltage | Phase voltae | Line-line voltage | Phase voltage | Line-line voltage |
| Case 1 | 12.15% | 5.56% | NA | NA | 5.33% | NA |
| Case 2 | 10.14% | 6.0% | NA | 7.84% | 7.78% | 6% |
| Case 3 | 12.17% | 5.35% | 2.37% | 5.62% | 5.58% | 7.48% |

- In general, line to line voltage presented lower voltage drop during transformer energization
- Customer side voltage drop, for both phase and line-to-line voltage, is lower than that of primary side phase voltage
- Customer side transformer with delta connection seems to help mitigate primary side phase voltage drop
- Primary side line-to-line voltage could be a good indicator for customer side voltage drop during transformer energization

*Detailed Findings – Supplemental Review*

# 1547-2018 Section 7.2.2

**Rapid voltage changes (RVC) - When the PCC is at medium voltage, the DER shall not cause step or ramp changes in the RMS voltage a the PCC exceeding 3% of nominal and exceeding 3% per second averaged over a period of one second.**

- Any exception to limits is subject to approval by the Area EPS operator with consideration of other sources of RVC within the Area EPS.
- These RVC limits shall apply to sudden changes due to frequent energization of transformers, frequent switching of capacitors, or from abrupt output variations caused by DER mis-operation.
- These RVC limits shall not apply to infrequent events such as switching, unplanned tripping, or transformer energization related to commissioning, fault restoration, or maintenance.

*Detailed Findings – Supplemental Review*

# 4. Distribution Protection

- **Duke Criteria**
  - Will the addition of the Generating Facility and its related fault current contributions exceed interrupting capability, cause miscoordination or nuisance tripping on the circuit?
  - A short circuit analysis is used to determine any impacts on protection coordination. Plant characteristics, circuit characteristics, and point of interconnection are used to determine if there are any other issues. If protection issues are indicated by addition of the Generating Facility, it fails Supplemental Review and requires additional study.
- **EPRI Rationale**
  - Adequate protection of both DER installations and the feeder need to be confirmed.
    - ✓ This includes exceeding steady state and short circuit duty ratings, limiting overvoltage contribution of DER (during switching and ground faults), meeting anti-islanding criteria, and overall fault detection sensitivity, relay coordination and reclosing schemes to minimize customer outage frequency and time.

*Detailed Findings – Fast Track / Supplemental Review*

# EPRI Recommended Practices Changes to 3.2.1.6

## 87.5% of Interrupting Capability

<u>Clarify Duke internal procedure</u>

- If the fault level at the device, without DER, exceeds the screen limit of 87.5%, then supplemental review is required.
  - Duke may also consider protection upgrades.
- If the fault level at the device, with addition of DER, exceeds 95% then an upgrade to interrupting capability is recommended as a condition of interconnection.
  - Typically this screen serves to verify interrupting capability or the need for a larger device rating such as a fused lateral connection of DER.

*Detailed Findings – Supplemental Review*

# 5. Substation Capacity Availability

- **Duke Criteria**
  - Does the aggregate generation connected downstream of the substation transformer bank exceed available capacity?
  - Nameplate rating (ONAN) of the transformer bank is used to determine available capacity.
  - Consideration can be given to the bank minimum load for generation that is co-located with load. If adding the Generating Facility may exceed the substation capacity, then it fails Supplemental Review and requires additional study.
- **EPRI Rationale**
  - Allocating circuit capacity is a recommended practice as is maintaining reasonable spare capacity. There is not a standard way to determine these.

*Detailed Findings – Supplemental Review*

# 6. Unintentional Islanding Risk

- **Duke's Criteria**
  - Does the addition of the Generating Facility, in aggregate with other queued ahead Generating Facilities, create a concern for unintentional islanding?
  - A review of the Generating Facility's inverter detection capability, service configuration, and transformer is performed in conjunction with the substation and/or circuit load demands.
  - Should the Generating Facility create a concern, remediation or further analysis is required.
- **EPRI's Rationale**
  - Although inverters are tested for islanding detection in the lab, the increased deployment, mix of DER and of detection methods in the field are relevant to risk.
  - Some detection methods are found to work better than others.

*Resume*

# Tom Key, Sr. Technical Executive, EPRI

## EDUCATION

- **MS, Electrical Engineering, Rensselear Polytechnic Institute, Troy, NY, 1974**
- **BS, Electrical Engineering, University of New Mexico, Albuquerque, NM, 1970**

## RESEARCH AND PROFESSIONAL EXPERIENCE

- **Electric Power Research Institute (EPRI)**, *Sr. Technical Executive | 2005 – Present*
  - Mr. Key currently manages EPRI distributed resources integration activities focusing on photovoltaic system integration into electrical distribution. He has been active in many standard developments for power systems and is a Fellow in IEEE for his work in the area of power quality. He has expertise in electric power systems, energy storage, renewable technologies, power quality, and related power electronics and system integration.
- **Power Electronics Application Center & EPRI Solutions**, *Vice President Technology and Technical Director | 1989 – 2005*
  - Mr. Key is a founder of EPRI's laboratory for power quality, distributed generation and end-use applications in Knoxville, TN and created a compatibility-related research program that provided new options to clients and an effective funding mechanism for pooling resources. He organized and managed a national power quality testing network.
- **Sandia National Laboratories,** *Manager, RDT&E for Utility Grid Compatible Interface | 1979 – 1989*
  - This work characterized high-performance of solar dc/ac inverters and electronic appliances, analyzed effects of power disturbances on sensitive electronic equipment, and developed design criteria and recommended practices for cost-effective application of power-enhancement equipment.

## SELECTED (of 150) PUBLICATIONS

- "Distribution Photovoltaic Monitoring Program," (co-author C. Trueblood et al.) at 4th International Conference on Integration of Renewable and Distributed Energy Resources, Albuquerque, NM, Dec. 2010.
- "Distributed Resources Standards" (co-authored with Dugan and Ball) IEEE Industry Applications Magazine Prize Paper Award, Volume 12, Issue 1, January/February 2006.
- Engineering Guide for Integration of Distributed Storage and Generation, (co-author P. Barker, et al.) EPRI, Palo Alto, CA. Dec 2012. 1024354

## AWARDS

- EPRI Lifetime Achievement Award, IEEE Power and Energy Society's Renewable Energy Excellence Award

## Resume

# Nadav Enbar, Principal Project Manager, EPRI

### EDUCATION

- **MA, Social Sciences, University of Chicago, Chicago, IL, 2004**
- **BA, University of Rochester, Rochester, NY, 1996**

### RESEARCH AND PROFESSIONAL EXPERIENCE

- **Electric Power Research Institute (EPRI),** Principal Project Manager, DER Integration / 2010 - Present
  - Nadav's research activities focus on the technical and utility business challenges associated with integrating rising levels of DER, primarily variable solar energy supplies, on the distribution system. More recent project work has involved analyzing utility DER interconnection practices, providing guidance on opportunities for improving utility interconnection procedures and protocols that are compliant with IEEE Std 1547-2018, and informing updates to utility technical interconnection requirements (TIR) documentation. Additional areas of study have included energy storage and solar-plus-storage business strategy appraisal, solar adoption diffusion modeling, PV market trend and pricing analysis, and next generation solar technology evaluation.
- **IDC Energy Insights,** Research Director / 2005 - 2010
  - Nadav managed P&L and research responsibilities for Energy Insights' Distributed Energy Strategies and Renewable Energy Strategies practice areas. In his role, he conducted strategic- and market-based custom projects for utilities, government, industry, and research organizations. This involved research, writing, and delivery of qualitative and quantitative reports and presentations on a range of renewable energy, distributive energy, energy efficiency, demand response, and environmental topics. During his time at IDC, Nadav also helped establish a renewable energy practice focused on the European, Middle East, and Africa (EMEA) marketplace.
- **Summit Blue (now Navigant) and Sieben Energy Associates,** Consultant / 2004-2005
  - Among Nadav's contributions as an independent consultant were the development of a five-year strategic energy efficiency plan for a large U.S. utility, a comparative assessment of the demand side management (DSM) portion of electric utility integrated resource plans, an evaluation of DSM modeling approaches, and an investigation of next generation boiler technology.

### SELECTED PUBLICATIONS

- *Comparing & Contrasting Utility DER Interconnection Practices*. EPRI, Palo Alto, CA: 2019 (forthcoming)
- *Assessing Opportunities and Challenges for Streamlining Interconnection Processes*. Final Report prepared for Minnesota Department of Commerce. Minneapolis, MN: 2017.
- *Interconnection of Distributed Generation in NY State: A Utility Readiness Assessment*. Final Report prepared for the New York State Energy Research and Development Authority and New York State Department of Public Service, Albany, NY: 2015.

### AWARDS

- EPRI Performance Recognition Award. 2012, 2014, 2015, 2016.

# Together...Shaping the Future of Electricity

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ATTACHMENT E



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# 2019 Interconnection Commissioning Update

Cyrus Dastur, Advanced Energy

September 13, 2018

# Topics

- Periodic Inspection Pilot Program Overview
- 2019 Q4 Conditional Commissioning Process
- 2019-20 Distribution Interconnection Program Snapshot



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# Periodic Inspection Pilot Program Overview

## Pilot Inspection Results for Uncommissioned DER

September 13, 2018

# Periodic Inspections: History

- Approx. 300 sites connected to Duke Energy distribution prior to mid-2016 with limited or no commissioning conducted by Duke Energy.
- Duke Energy decided to pilot periodic inspections of these older sites to determine the scope and process for a periodic inspection program.
- Pilot inspections were conducted in 2018 (4 sites) and are ongoing in 2019 (5 sites).

# Periodic Inspection Pilot: Design

- Pilot sites ranged in capacity from 2-5 MW and entered service 2012-2015
- All sites were inspected from the AC side of the inverters to the point of interconnection (POI)
- Inspection scope (STILL BEING DEVELOPED):
  - Expected vs. installed equipment
  - Interconnection construction – safety & reliability issues
  - Inverter settings: grid protection, power factor, max. export capability, and grid reconnection
  - Commissioning test (cease-to-energize & restart delay)
- Inspection and test were completed in one site visit, with goal of minimizing site down-time

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# Overview of Findings

## Expected vs. Installed Equipment

- ☑ 2 sites
- ☒ 6 sites

## Inverter Settings

- ☑ 1 site
- ☒ 7 sites
  - Grid protection: 6
  - Reconnect timer: 2
  - Maximum export: 3
  - Power factor: 1

## Construction Issues

- ☒ All sites have some safety and reliability issues

## Commissioning Tests

- ☑ 4 sites
- ☒ 1 site restarted prematurely after grid restoration

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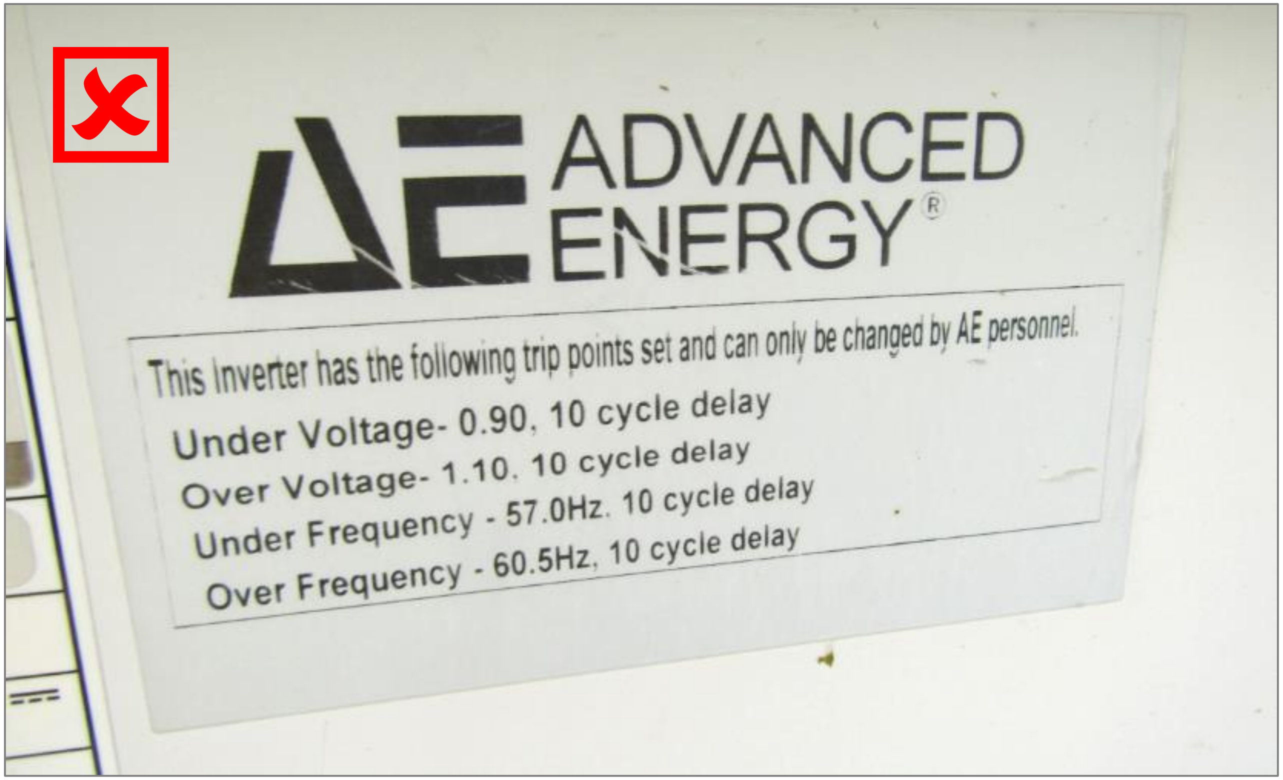
# Commissioning Tests

- Older DEC reclosers with SEL 351R control can't do single phase testing
  - Requires more Duke Energy resources
  - Need DEC equipment inspector with a bucket truck and capability to operate cutouts with loadbuster tool
- DEP reclosers with SEL 651R control and correct software can do single phase testing

# Construction: Mis-Labeling

Inverter is labeled with protection settings and a statement saying they can only be changed by manufacturer's personnel, but the label does not match the programmed settings.



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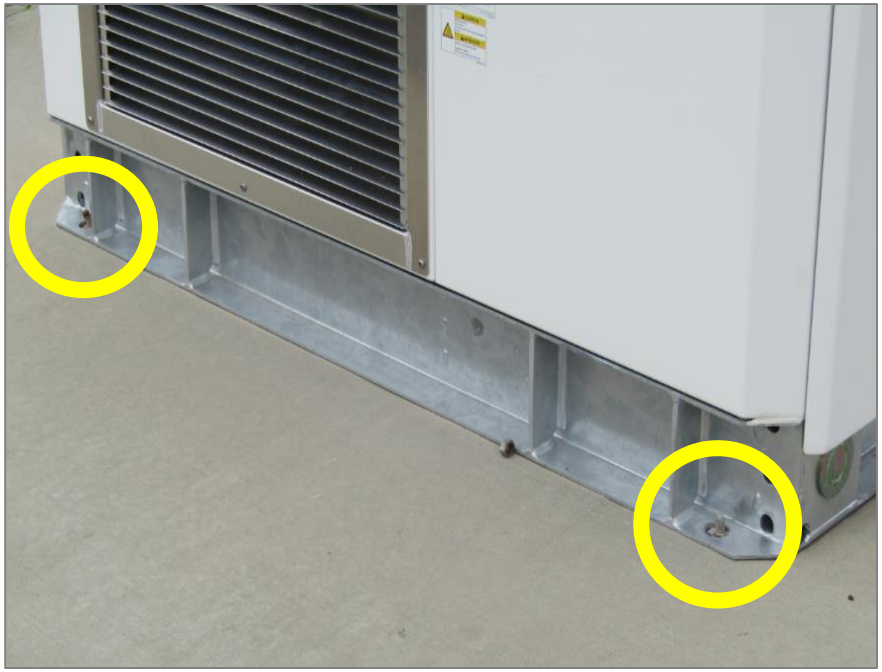
# Construction: Incorrect Tap Settings

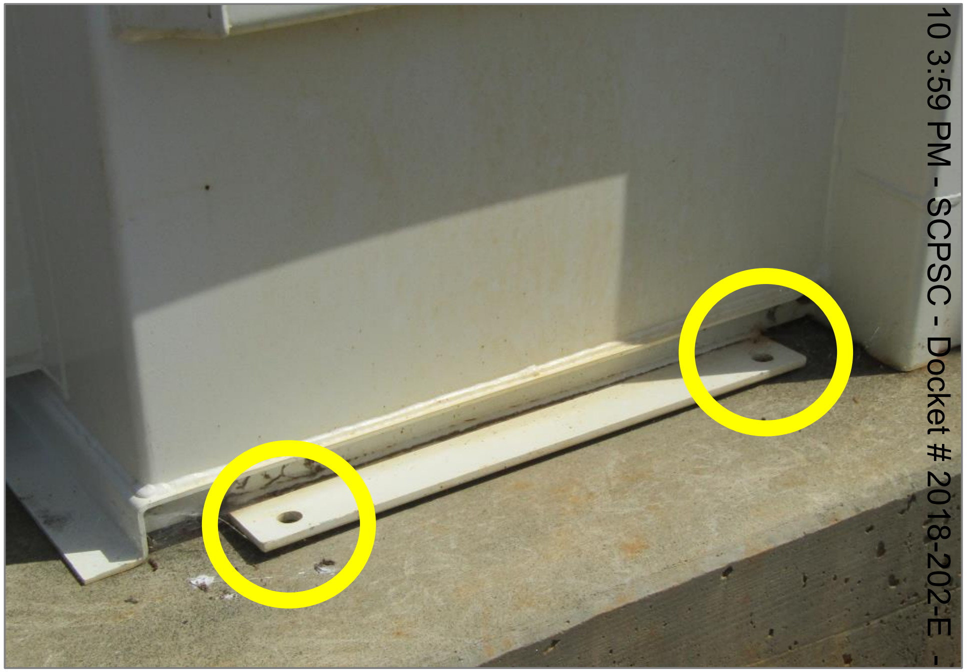
Transformer taps not set to C/3 causes inverter settings to be out of compliance with the site Interconnection Agreement and IEEE 1547.


# Construction: Unsecured Equipment

Replacement inverter not secured to pad after flood event.



MV transformer not secured to pad.



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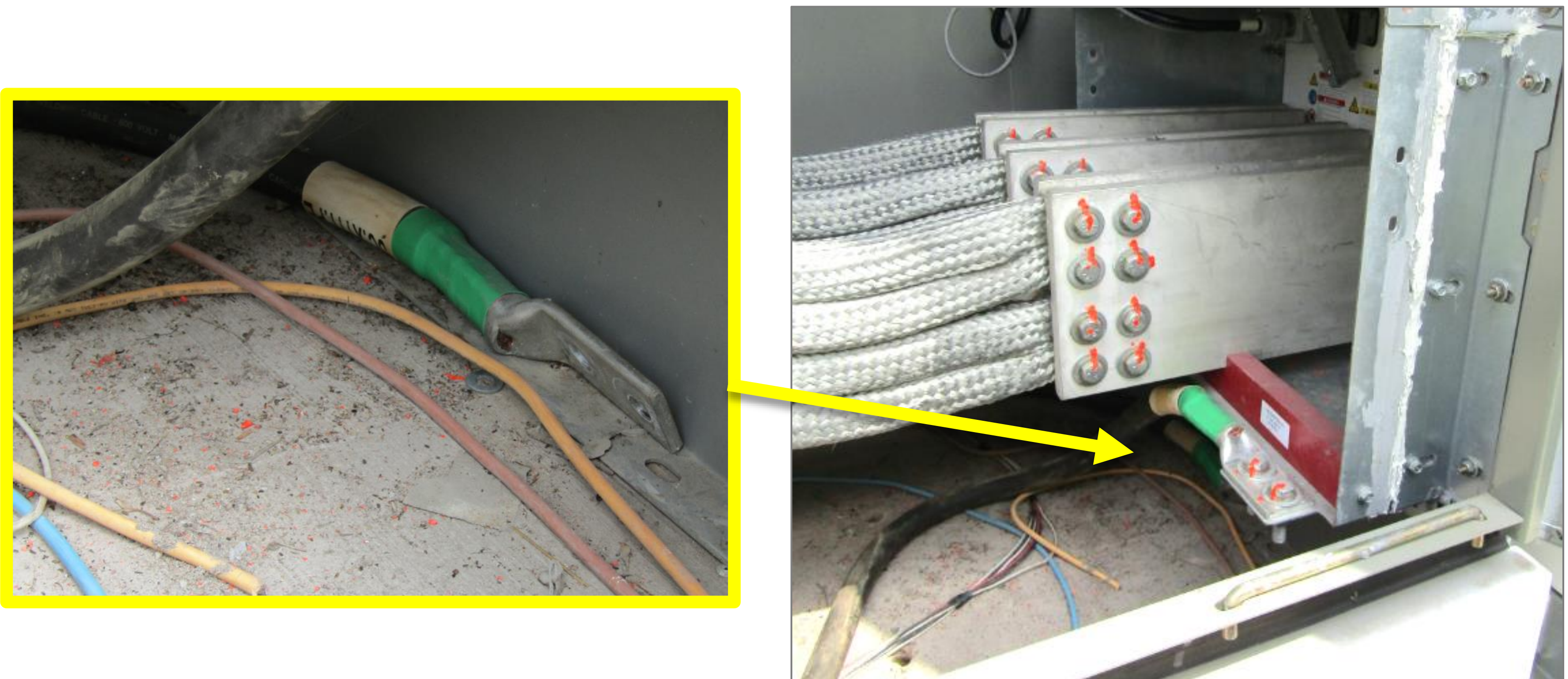
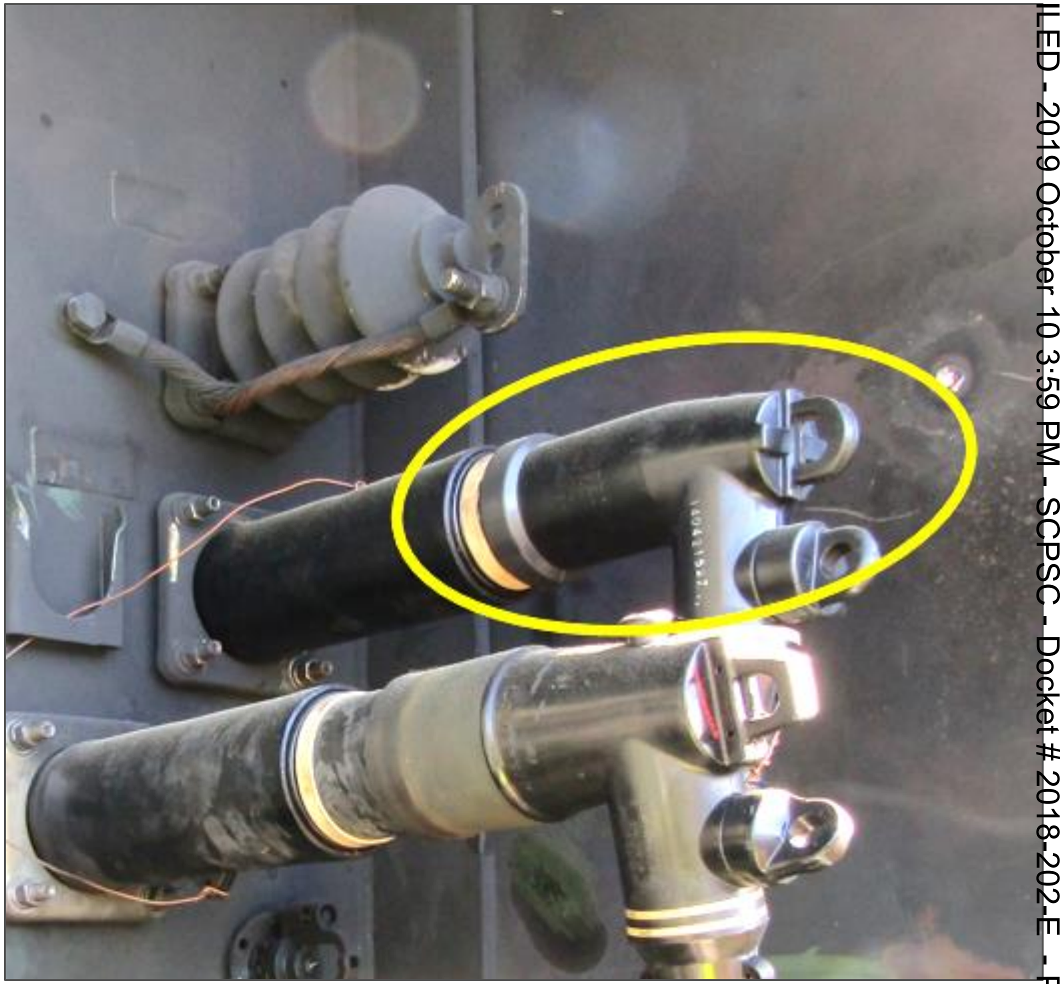
# Construction: Inadequate Repair

When an inverter was replaced, the 500 kcmil flexible ground cable was not reconnected.



# Construction: Inadequate Repair

Replacement elbow has a different voltage rating than the original, and the compartment hasn't been cleaned after the failure.



# Construction: Undersized MV Cable

The MV cable at the riser pole is severely undersized:

- 1/0 AWG AL MV cable is rated for 160 Amps at riser
- Site amperage is 232 Amps

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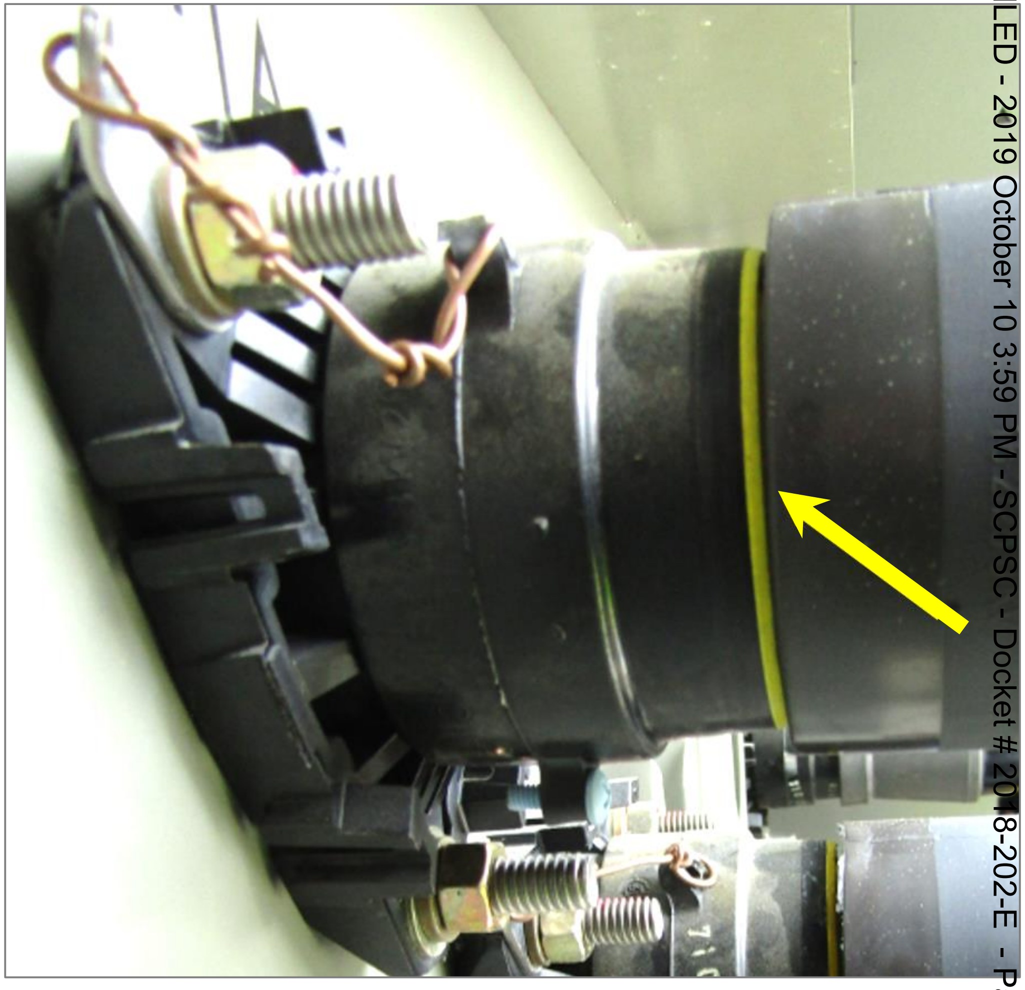
# Construction: Unseated Elbow Terminations

- Elbow terminator is not fully seated on the bushing, increasing the risk of an arc inside the transformer.



# Construction: Transformer Lightning Arresters

- The transformer at the end of the line in the underground feeder does not have lightning arresters installed on the terminal primary bushings.
- A lightning surge will double and reflect back up the line on the MV cable.

# Construction: Conductor Clearance

- Insufficient phase-to-ground clearances are an issue on the riser- and meter poles of many older sites.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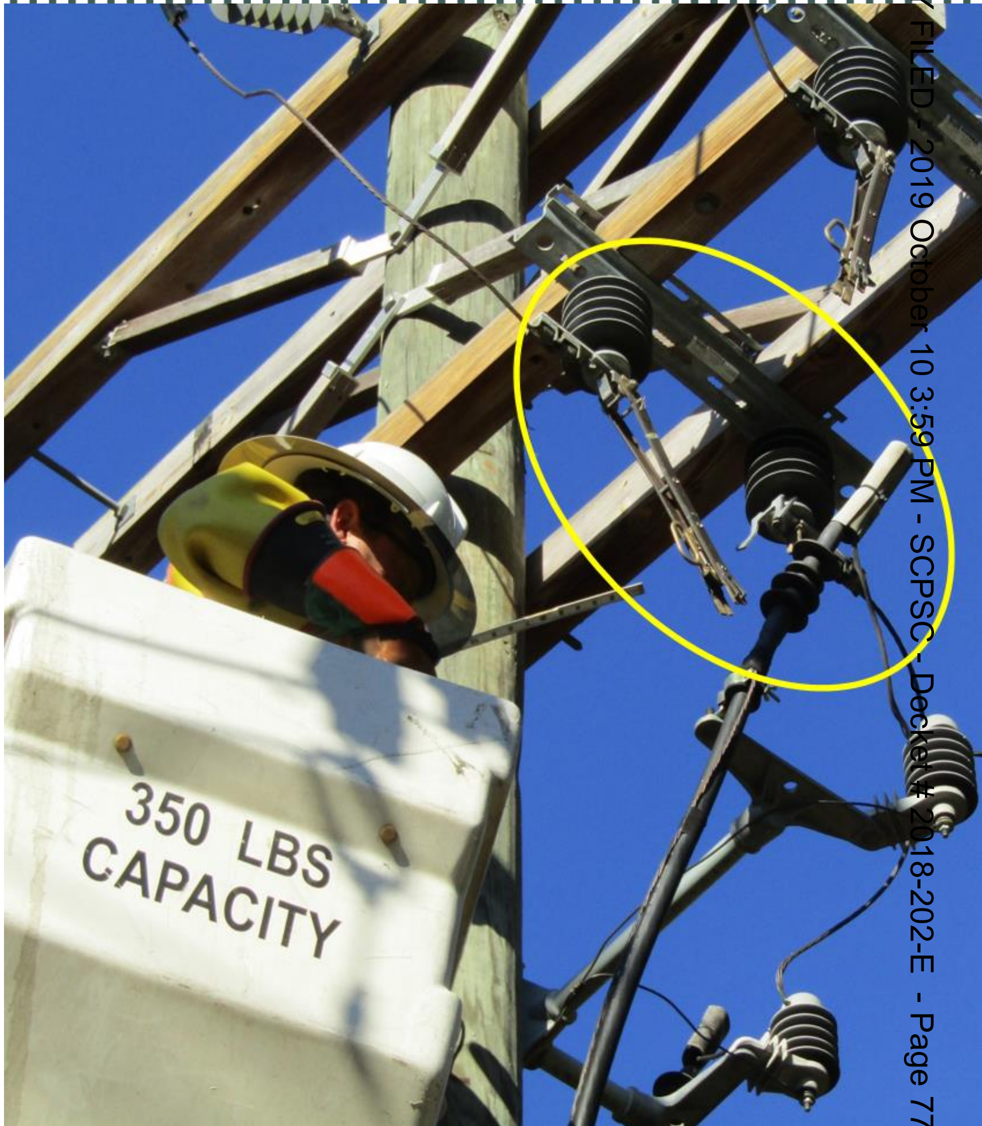
# Construction: Conductor Clearance

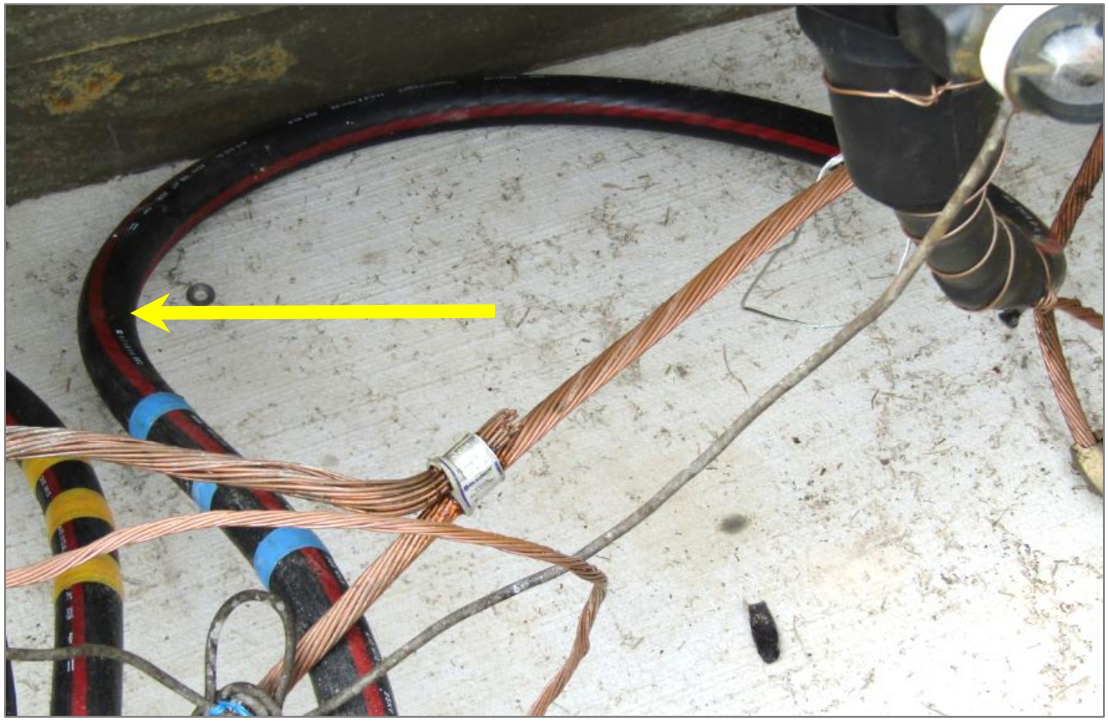
Unsafe customer cutouts with insufficient clearance

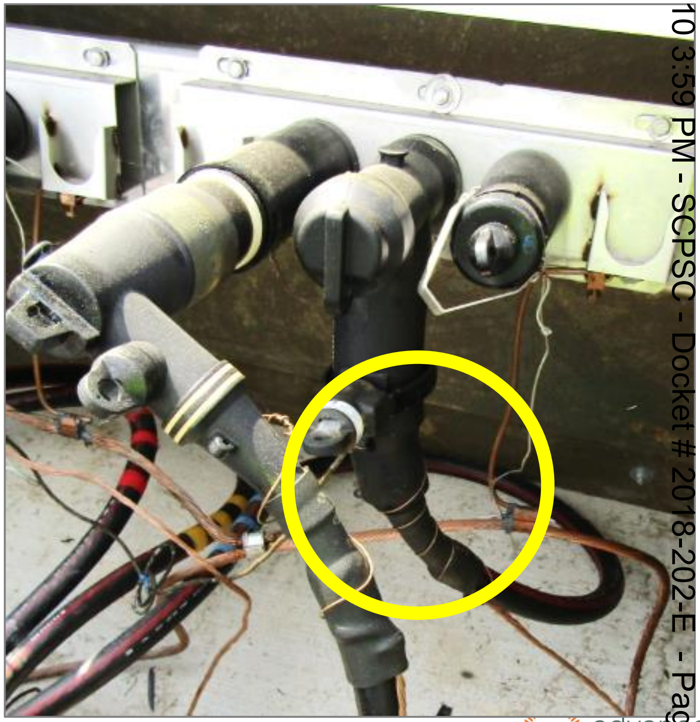
- Middle phase cutout is too close to outer phase terminator
- Less than 6 inches phase-to-phase clearance when opening middle phase switch
- Approximately 8 inches phase-to-ground clearance when opening switch



# Construction: Cable Bend Radius

Excess MV cable length in a junction enclosure causes bend radiuses that are too tight and deformation of the elbow terminators.





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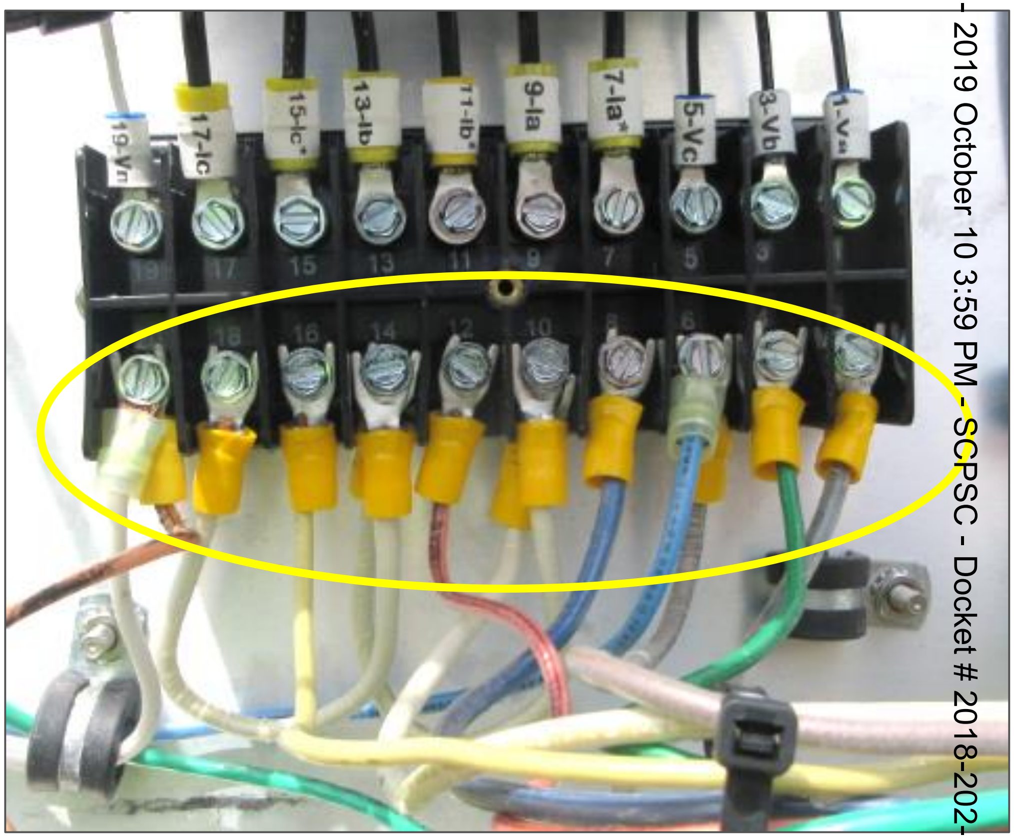
# Construction: Meter Wiring

Crimp connectors at the SEL 735 test switch were loose, and the enclosure was not grounded.

- Resulted in an unsafe open circuited CT
- Site had to be de-energized by the Duke Energy recloser
- Connections had to be re-crimped and terminated before returning the site to operation

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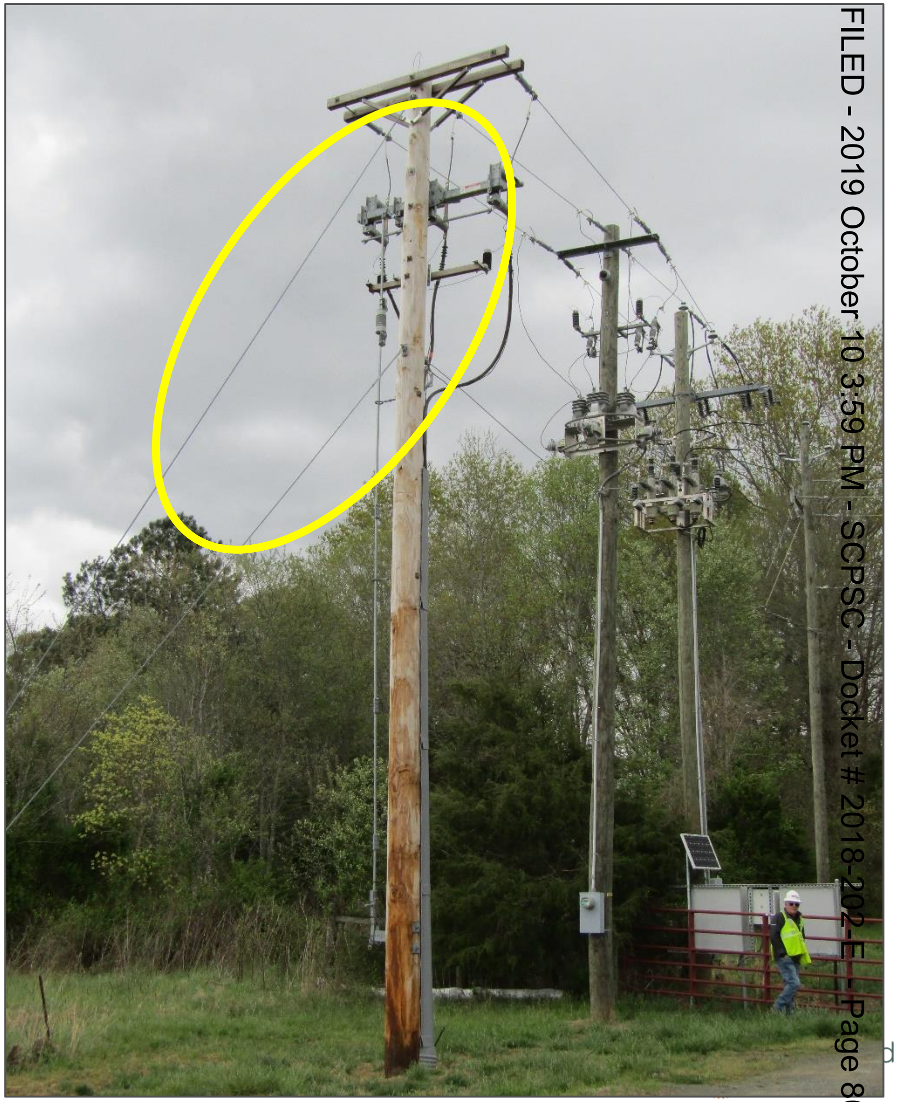
# Construction: Ungrounded Guys

- The upper guy wire at the riser pole is installed above energized parts and does not have a guy insulator stick.
- The guy wires at the riser pole are not grounded.
- The guy wires are landed outside the site fence, creating a risk to the public.



# Construction: GOAB Grounding

The GOAB switch frame is not grounded and the control rod insulator is located too close to grade level, creating a hazard for the switch operator.

# Periodic Inspection Program

- An inspection program for uncommissioned DER is still under development.
- The current scope of work is likely to change, with a goal of further streamlining or simplifying the process.

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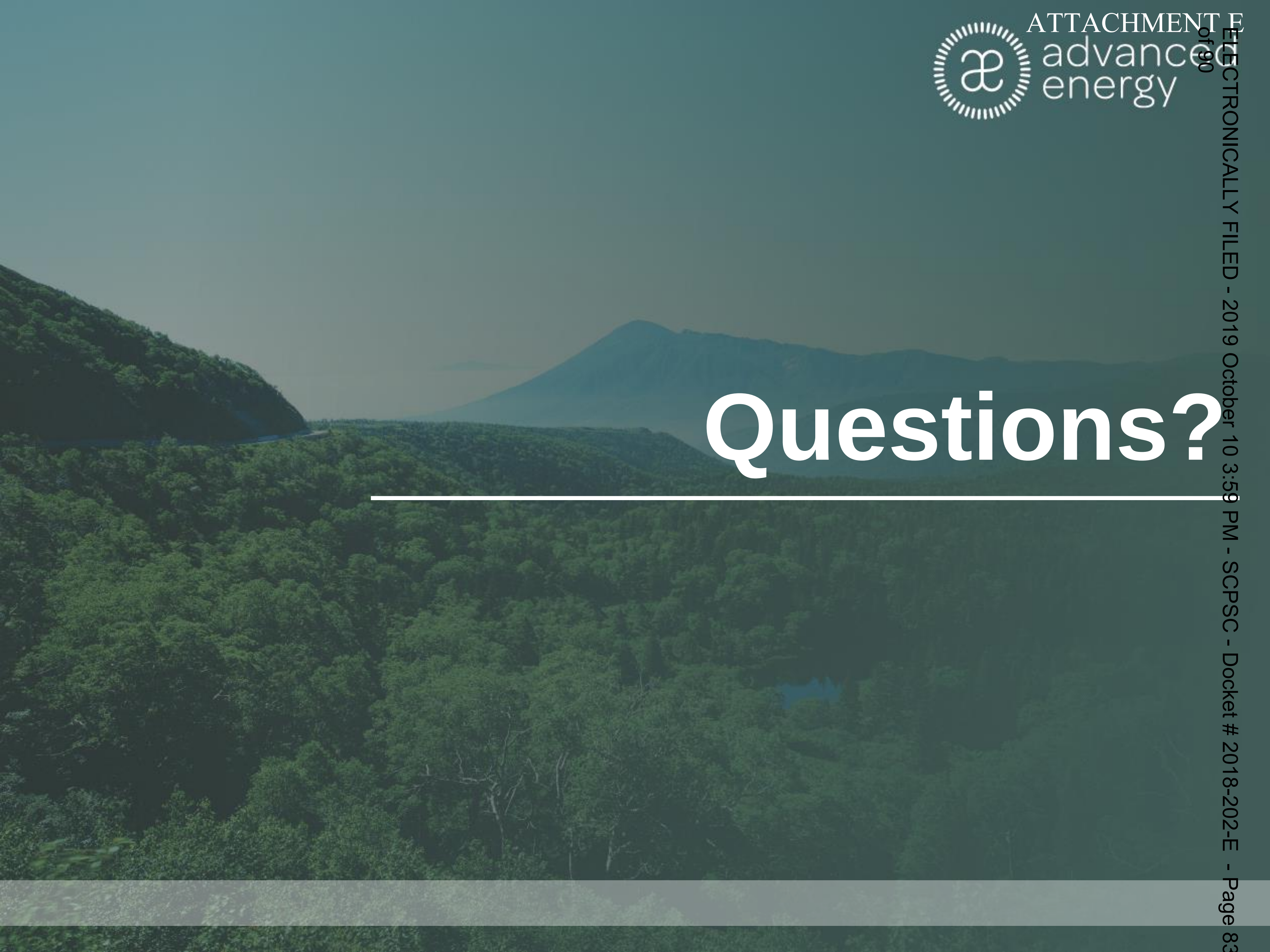

# Questions?

# 2019 Q4 Conditional Commissioning

September 13, 2019

# Q4 Commissioning – Key Dates

- Conditional process starts October 1, 2019
- Inspections should be completed no later than November 27, 2019
- Commissioning tests should be completed no later than December 23, 2019
- December 26, 27, 30 and 31 are reserved for inclement weather make up days
- No site visits on weekends, Thanksgiving (Nov. 28-29) or Christmas (Nov. 24-25).
- Sites that fail a commissioning test are not guaranteed a re-test date in 2019.



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# Q4 Commissioning - Requirements

- Site fence and access road to DE poles must be complete to receive safe-to-energize status (along with all other identified safety corrections).
- Commissioning test can be scheduled once the site is energized.
- PV array construction must be complete prior to the conditional commissioning test.



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# Q4 Commissioning - Requirements

- Inverter settings must be correct prior to conducting the commissioning test.
- Inrush mitigation systems must function correctly during testing.
- Weather conditions must permit the site to generate at least 20 percent of the site’s full rated AC current in order to conduct the commissioning test.

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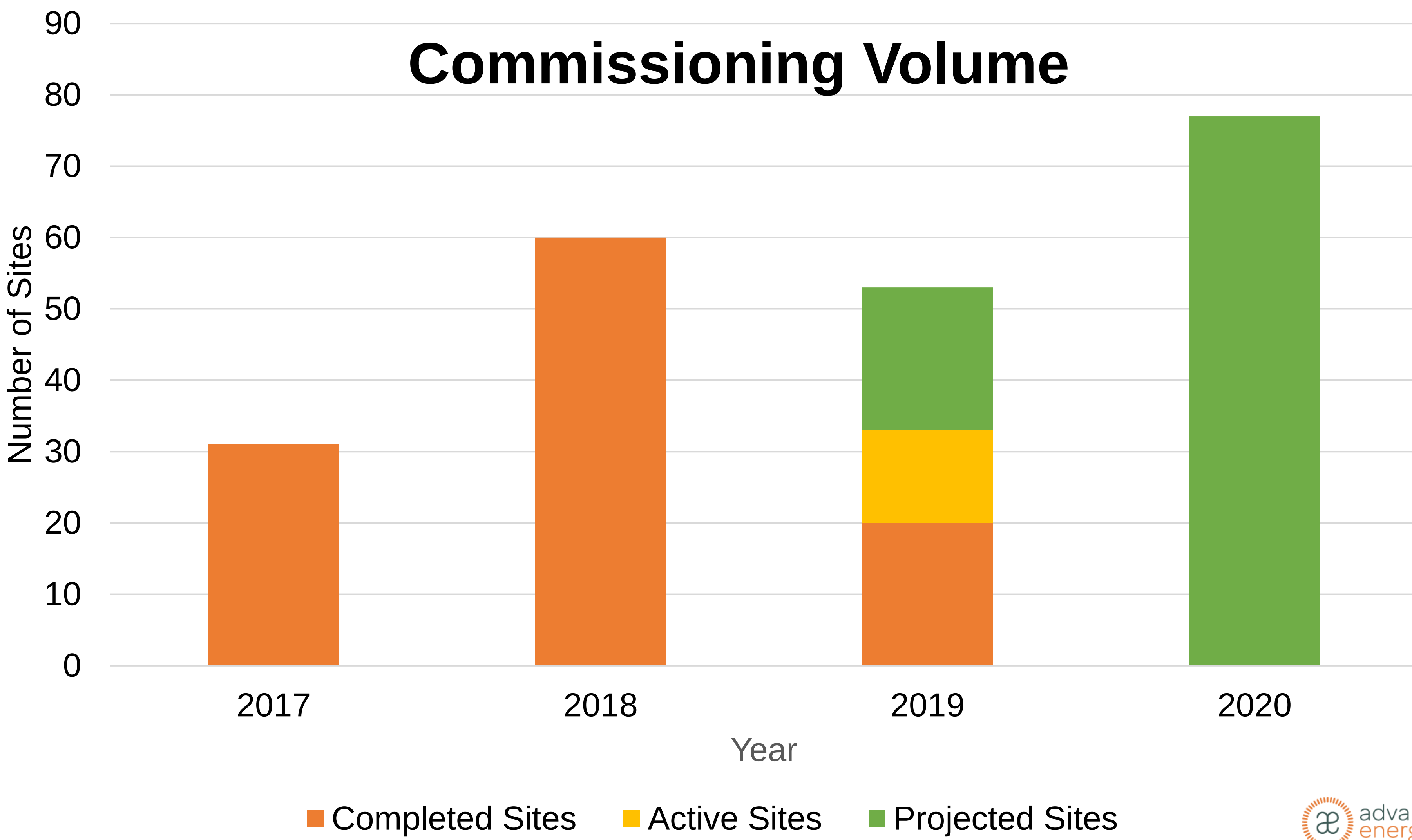
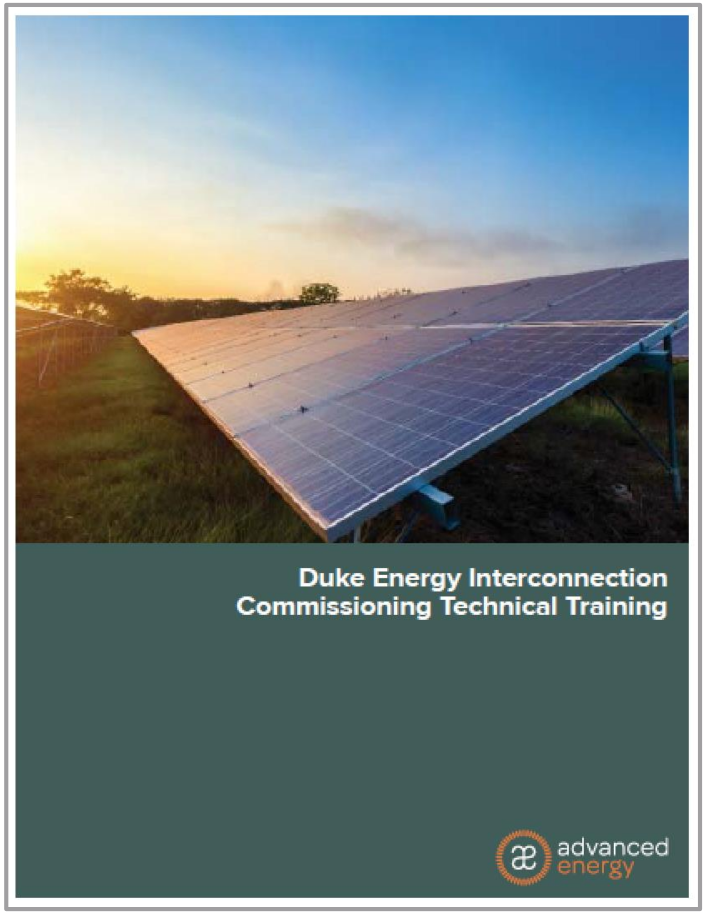
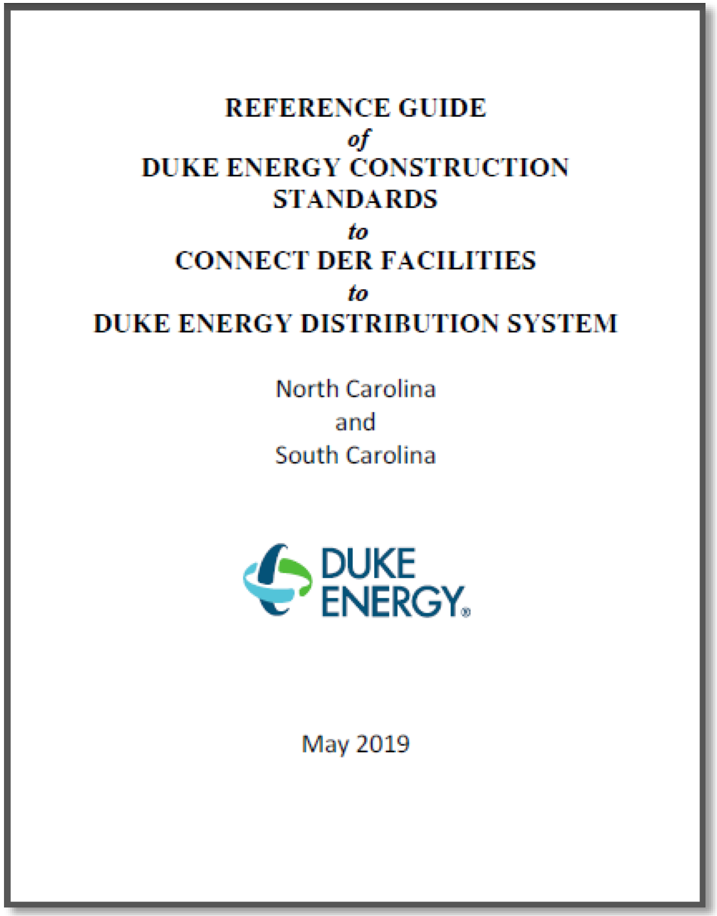
# Interconnection Program Summary



# Interconnection Program Summary

- **Industry Training and Reference Guides:** https://www.duke-energy.com/business/products/renewables/generate-your-own/tsrg



REFERENCE GUIDE
*of*
DUKE ENERGY CONSTRUCTION STANDARDS
*to*
CONNECT DER FACILITIES
*to*
DUKE ENERGY DISTRIBUTION SYSTEM

North Carolina
and
South Carolina

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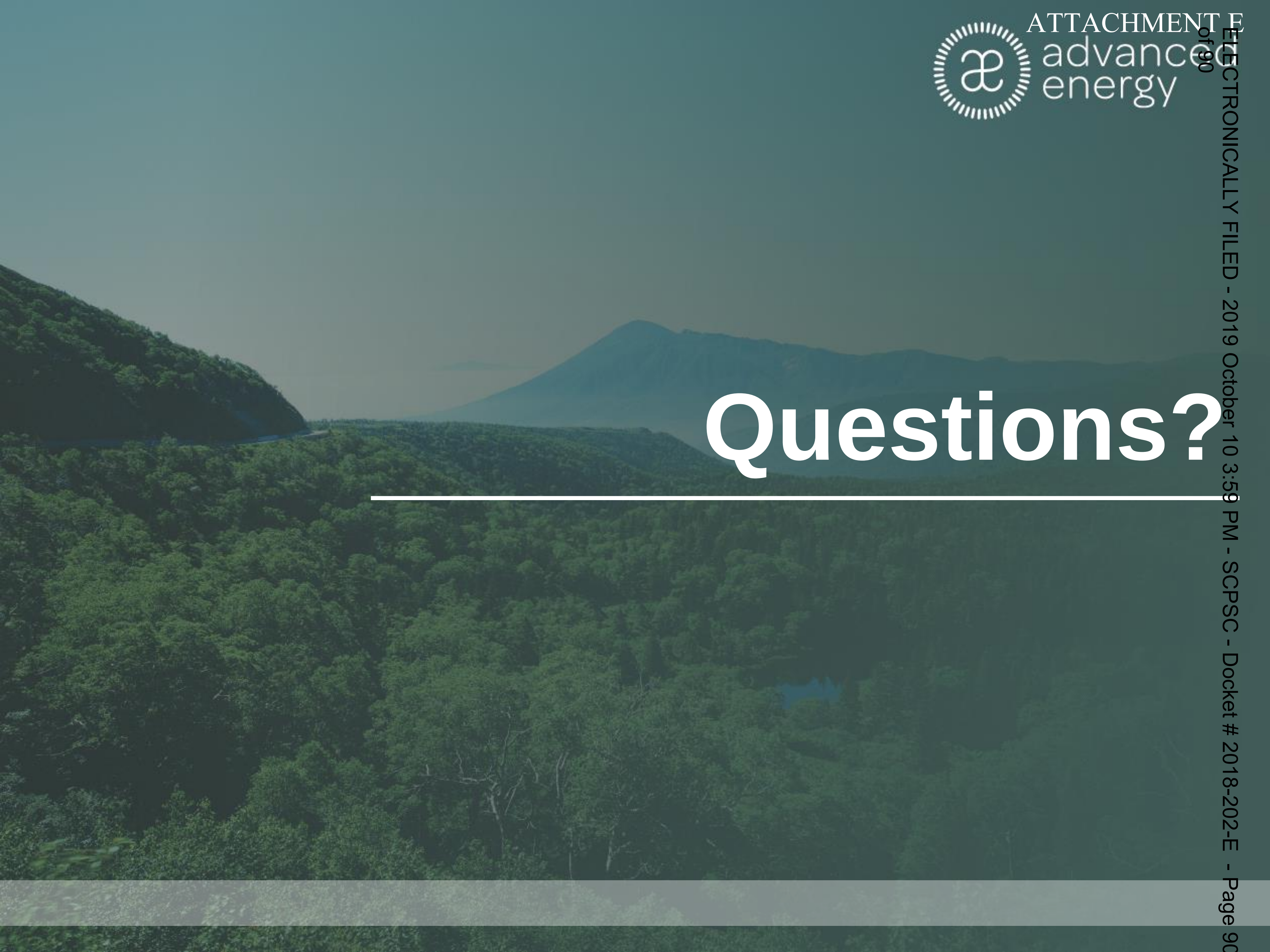
May 2019



# Questions?